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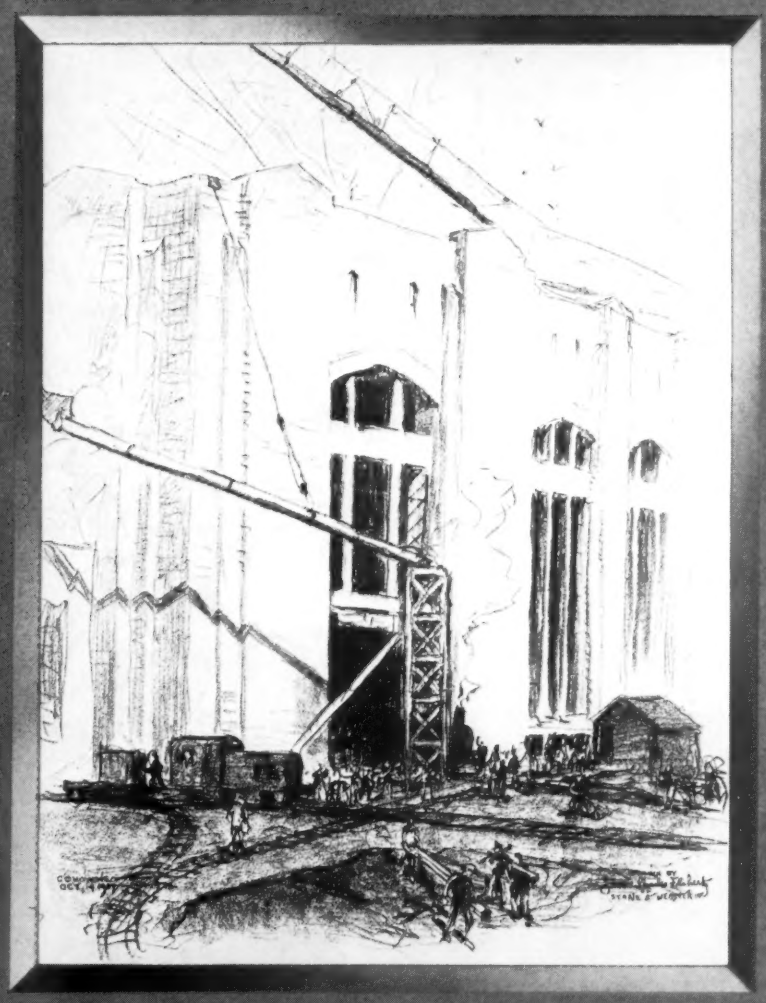

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
VOL. VIII, NO. 7 DECEMBER, 1927

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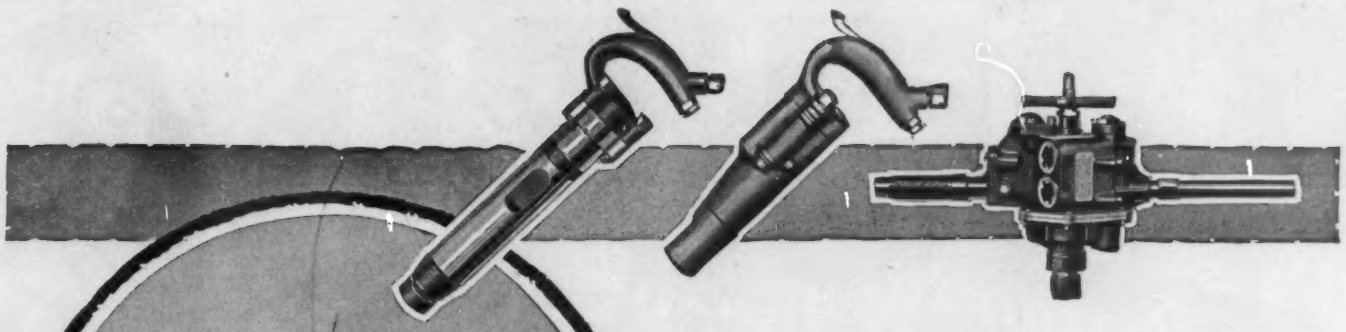

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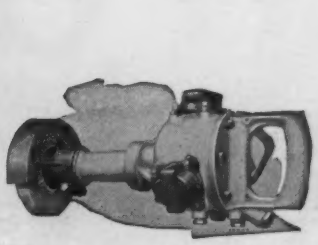

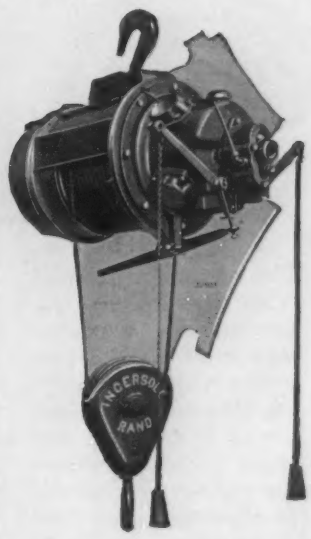

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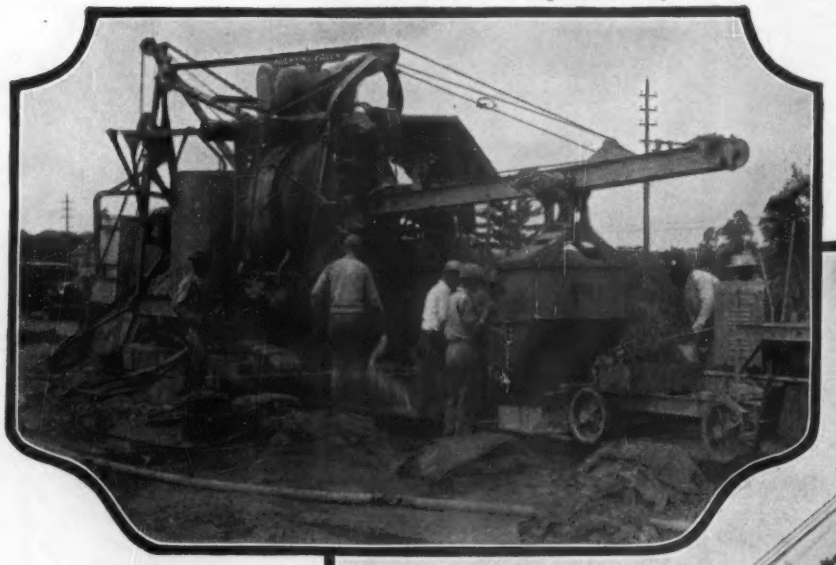

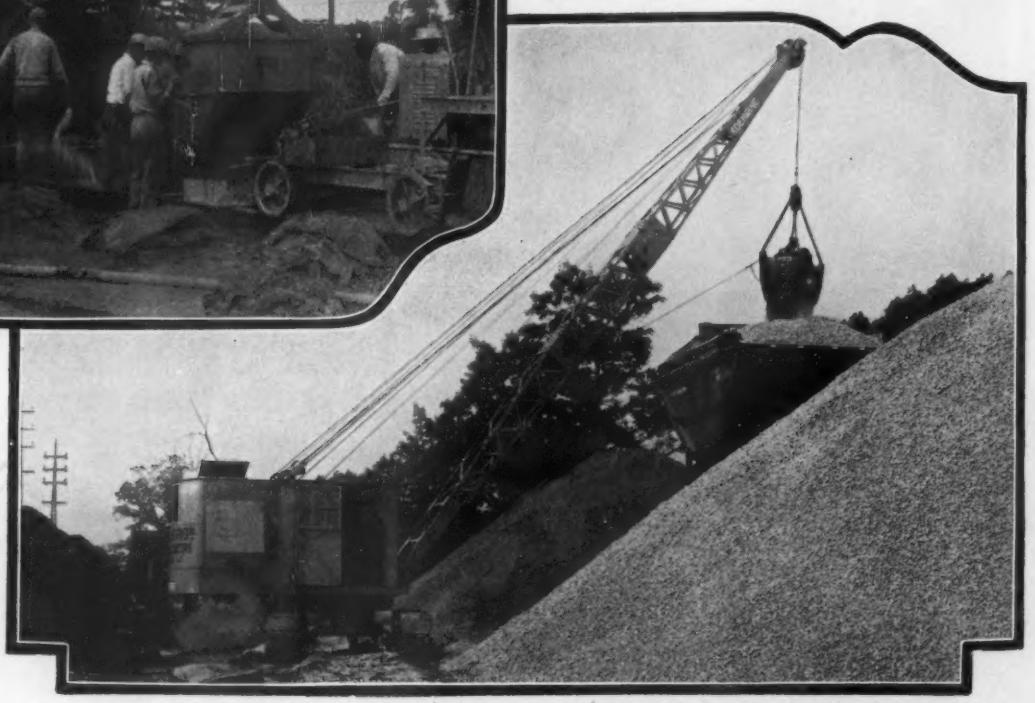

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DEC16'27

THE TECH ENGINEERING NEWS

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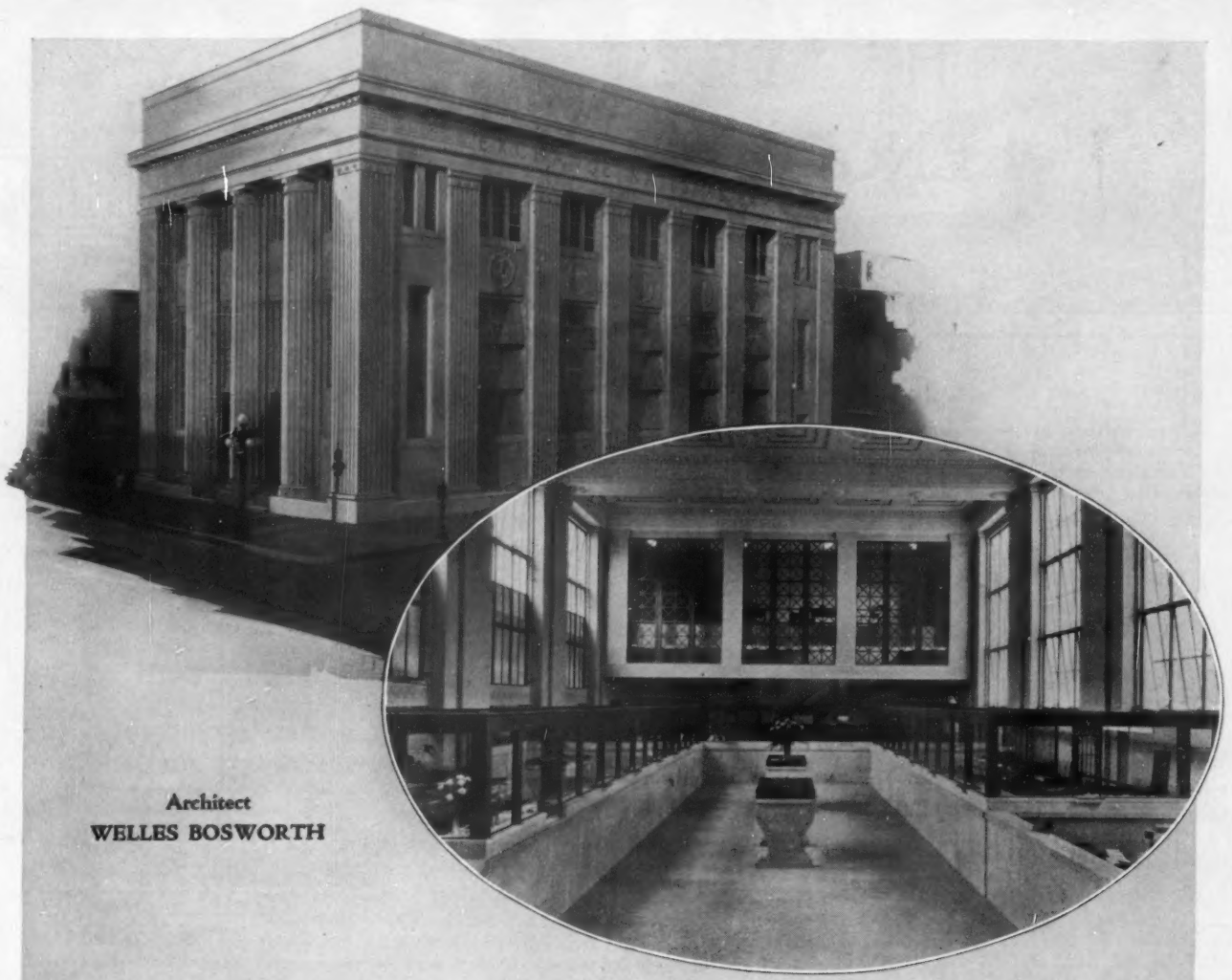

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THE TECH ENGINEERING NEWS

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Industrial Health Hazards

A discussion of the causes and effects of industrial disease

By HUGH S. CUMMING
Surgeon-General United States Public Health Service

WITH the tremendous strides that industry has made in the past half century, our attention has been more and more directed towards the effect of occupation on the health of workers. In part, this has been due to the increasing number of states which require the payment of compensation for occupational diseases as well as accidents, but it has been due also, to no little extent, to the fact that industry itself has come to a better understanding of the desirability of protecting the health of its employees.

When we think of the health hazards of the present day we are apt to believe that we are entering upon the consideration of an entirely new subject. As a matter of fact, this is only partially true, and, to a large degree, the health problems which confront industry at the present time are the result of the same old health hazards which have been borne by the worker since the first day he turned his hand to extract a living from Mother Earth.

It is manifestly impossible to discuss, however briefly, even the more important of the many health problems which are found in industry. Fortunately, from a public health point of view we have two reasonable measuring rods which limit our discussion; the first is the importance of the hazard as it affects the health of the worker, and the second is the number of workers affected by any particular hazard.

Probably the largest group of workers exposed to any particular health hazard are those engaged in the dusty trades. The dust hazard is not a new one, for even among the ancient Greeks we have record of the use of respirators as an aid in preventing the breathing of dust. Old as it is, dust still constitutes the same serious menace to health that it did in those early days, and in no other type of industry does the effect of a hazard on health stand out so vividly as in these trades.

It has been possible through the use of occupational mortality statistics to obtain rather exact information as to the causes of death and their relative importance in the industrial population. Furthermore, since the employed group has been divided into certain broad occupational classifications, it is possible to compare these occupational groups and determine the percentage of total deaths resulting from a particular type of disease or diseases. In this country Dr. Kober has analyzed the percentage of deaths from tuberculosis in certain occupations, based upon the industrial experience of several insurance companies. The percentage of deaths caused by tuberculosis in all occupational groups was 14.8 per cent. The rate varied from 5.6 per cent and 5.8 per cent among lumbermen and raftsmen and coal miners, respectively, up to 54.2 among slate pencil workers, and 77.8 per cent among flint nappers and burrstone dressers. This tremendous variation in percentage of total deaths in different occupational groups due to tuberculosis must have some explanation, and if we examine the tables presented by Dr. Kober we will find that the majority of the occupational groups experiencing a high rate from tuberculosis are those in which there is exposure to dust.

DANGEROUSLY DUSTY

The high percentage of silica contained in the dust from this type of work is very injurious to the worker's lungs.

Public health has contributed a great deal to the better knowledge of the dust hazards in industry. Investigations have discovered for us the fact that the dusts which appear most dangerous are those in which free silica is found, and those which are least dangerous are the ones containing a high per cent of calcium. Our studies have given us a general idea of the trades in which dust is a health hazard. We know roughly the severity and nature of the diseases that exposure to dust produces, and pathological investigations have suggested the manner in which the dust acts after it enters the human body. Of still more importance is the fact that we know that if the dust count in any particular occupation can be kept under certain limits, depending on the nature of the dust, that we can go very far in preventing the development of silicosis, and especially the development of the tuberculosis which usually follows.

The great health problem which confronts the dusty trades is the economic control of the dust hazard by mechani-

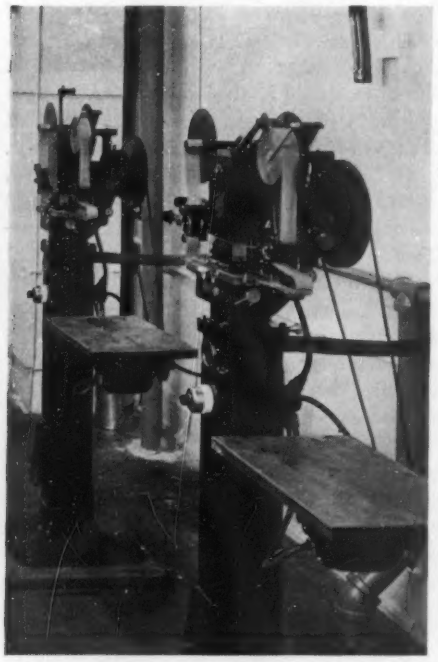
(*Continued on page 320*)

The Technicolor Process

An application of scientific research to the motion picture industry

By LEONARD T. TROLAND, '12
Director of Research,
Technicolor Motion Picture Corporation

THE endeavor to secure photographs in natural colors has occupied the attention of inventors for over seventy-five years. However, in spite of the many ideas which have been advanced, the commercial developments from these efforts have been very meager. The only outstanding application of color photography, up to the last few years, has been in connection with the photo-mechanical processes of printing which are responsible for the color half-tone reproductions used in our magazines. A few photographic processes for color work have been placed on the market, but they have failed to secure any very wide use.



FILM PERFORATORS

The film with its green and red impressions is punched to receive the projector teeth on these machines.

The most promising industrial field for color photography is apparently that of the motion picture. The first commercial attempts to introduce natural colors into the movies were made by Urban in his so-called Kinemacolor process about 1909. This process depended upon an alternation of red and green pictures on the screen in such rapid succession that they fused together in the eye. The film itself had no color on it, although it carried a record of the colors in black and white, the colors being introduced by means of a rotating sector wheel carrying filters and forming part of the projector. As the red and green images were photographed in the camera one after the other, a moving object was displaced between the red and the green, with resulting bad registration, or "color-fringing" on the screen. This effect limited the application of the Kinemacolor process to the photography of movements having a very low angular velocity.

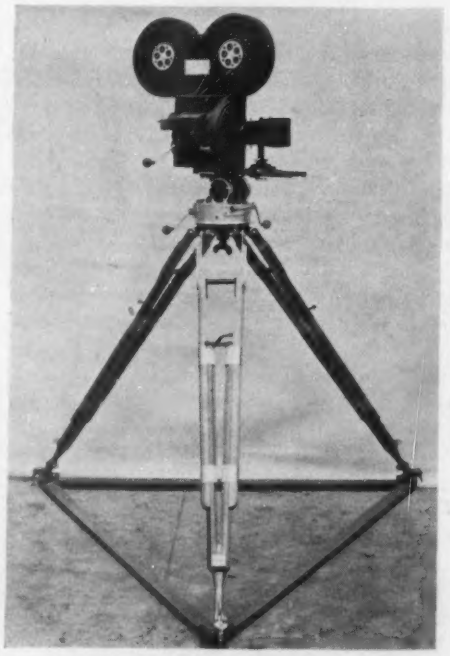
The first commercial motion picture positive having the colors actually on the film was manufactured by the Prizma Co., who produced a complete photoplay, "The Glorious Adventure," by their process. However, the photography was still subject to the defect of color-fringing, and the general quality of the result was apparently not sufficiently good to make the process a commercial success. Numerous other experimenters have devoted their efforts to this problem, but the first process to conquer all of the practical difficulties, and to reduce the manufacture of colored motion picture positive to a reliable industrial operation, is that perfected by the Technicolor Motion Picture Corporation of Boston. The work of the Technicolor group on this subject was begun in 1915 and, except for an interruption during the participation of the United States in the World War, has continued since that time. The first Technicolor pictures, which were shown publicly in 1917, utilized a special projector which projected red and green images simultaneously rather than successively upon the screen. The negative involved simultaneous exposure of the corresponding images, so that color-fringing was eliminated. However, the inconvenience of a special projecting machine led to the abandonment of this system and the introduction of a film carrying the colors directly upon its surface.

The original Technicolor positive film had the so-called "double-coated" structure with emulsion on both sides of the celluloid base, one carrying a red and the other a green image. The first subject to be released publicly, using this film, was a 4-reel photoplay, featuring Anna May Wong, entitled "The Toll of the Sea." This was followed by a series of "inserts," or restricted lengths of colored films, introduced into photoplays which were otherwise in black and white. Such inserts have been used by practically all of the motion picture producers to embellish their photoplays, the total number running into hundreds. Among the more important feature productions employing an extensive amount of Technicolor film may be mentioned "The Ten Commandments," "Ben Hur" and the "King of Kings."

In addition to these inserts, a complete photoplay was made by Famous Players Laskey Corporation, featuring Jack Holt and Billy Dove, entitled "The Wanderer of the Wasteland." More recently a full production, using the Technicolor process, was released by Douglas Fairbanks under the title "The Black Pirate." The present trend of color work appears to be in the direction of so-called short subjects involving one or two reels of film and constituting in themselves a complete story. A large number of such subjects have been made and released, using the Technicolor process, by Colorart, Inc. of Boston and Colorcraft, Inc. of Hollywood.

Since the beginning of 1927, all Technicolor film has been manufactured by a new single-coated process which yields a film having an emulsion coating on only one face, thus resembling ordinary black and white film in structure. This film avoids certain practical difficulties which are characteristic of all double-coated film,

(*Continued on page 310*)



COLOR CAMERA

Inside is a prism which allows the red and green values of the picture to be recorded at the same instant, one above the other.

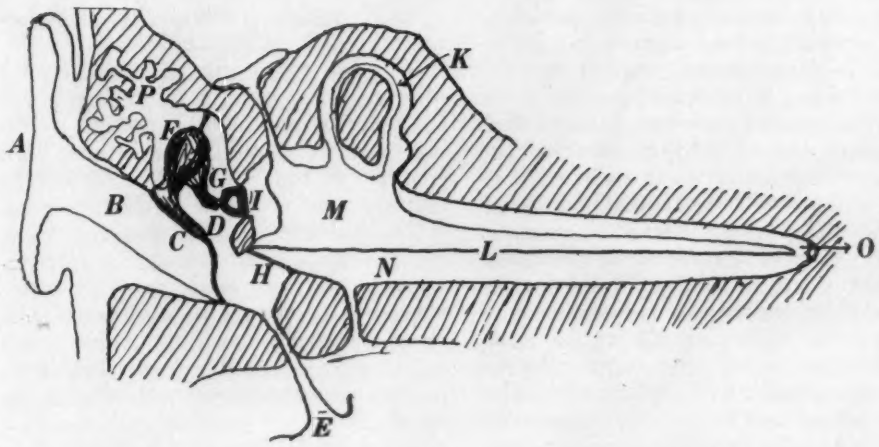


FIG. 1
Cross section of the human ear showing the connection and coördination of its parts

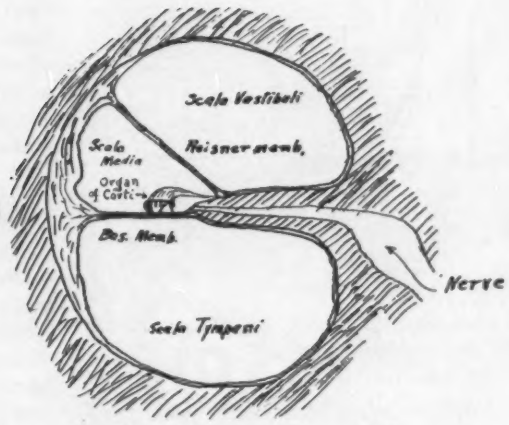


FIG. 2
Transverse section of a whorl of the cochlea, showing position of the membranes

The Ear and the Sensation of Hearing

New light on the function of the ear as revealed by the work of the Bell Telephone Laboratories

By WILLIAM R. BARSS
Assistant Professor of Physics
Massachusetts Institute of Technology

THE purpose of this paper is to present to its readers a brief synopsis of the work that has been done, first in the study of the structure of the human ear, and second in the physical interpretation of this study leading to some theories relating to the sensation of hearing. Helmholtz[1] was probably the first physicist to undertake such a study. The advances made in telephone communication have made further study advisable, and during the last decade considerable valuable research has been done, chiefly at the Bell Laboratories in New York City. It is from the results of this research that most of the material in this article has been taken.

Structure of the Ear

Fig. 1 is a diagram representing a vertical section of the ear. Starting from the outside, we have first the external ear (pinna) A, from which extends the ear canal (external auditory meatus) B. This ends at the drum skin (membrana Tympani) C. Beyond this lies the cavity which is properly the ear drum (Tympanum) D. From the drum space the eustachian tube E, proceeds to the pharynx. This tube is usually closed, but opens when swallowing occurs, thereby bringing the air in the drum space to atmospheric pressure. The drum space is bridged across by three little bones called the hammer (malleus) F, the anvil (Incus) G and the stirrup (stapes) I. One part of the hammer is attached to the drum skin, while another part articulates with the anvil. A process of the anvil articulates with the apex of the stirrup. The base of the stirrup is attached to a membrane which closes an oval window (fenestra ovalis) in the bony wall which forms the inner limit of the drum space. In this bony wall, there is, in addition, a round window (fenestra rotunda) H, also closed by a membrane. Beyond the inner side of the drum space, lies the innermost part of the organ of hearing called the labyrinth. First there is the bony labyrinth or hollow excavated in the bony substance itself. Second, there is the membranous labyrinth, a structure similar in shape to the bony labyrinth and enclosed in it. The membranous labyrinth contains a liquid called the endolymph. The space between the bony labyrinth and the membranous labyrinth is filled with another liquid called the perilymph. The membranous labyrinth also contains the vestibule, the three semicircular canals K, and the cochlea which is a spiral canal shaped like a snail shell. The latter is divided for the greater part of its length by the lamina spiralis. In Fig. 1 the cochlea is represented as unrolled. The space above the lamina spiralis L, is known as the scala (region) vestibuli M, and the space below the lamina spiralis as the scala (region) tympani N. The two scala are connected at the helicotrema O. The liquid in the scala vestibuli is connected directly to the oval window and that in the scala tympani to the round window. The mastoid chambers P are connected with the drum space.

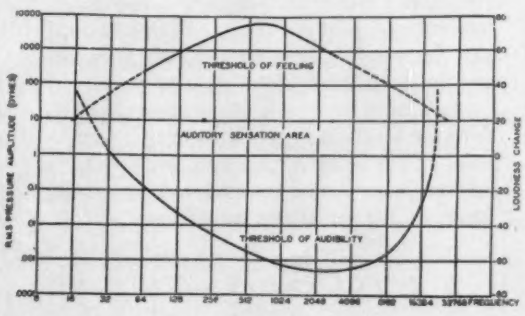


FIG. 3

Fig. 2 represents a transverse section of a whorl of the cochlea. In addition to the scala vestibuli and the scala tympani, this section shows the membraneous portion of the cochlea. In this region the membranous labyrinth is almost triangular in section. The upper side of the triangle, known as the membrane of Reisner, is thin and simple in character. The lower side is very complex and is the heart of the hearing mechanism. Its outer part is formed by the basilar membrane, on which rests the organ of corti. This organ comprises the inner and outer rods of corti and various other minute structures. The portion of the basilar membrane, which supports the organ of corti, is thin and not highly specialized. The outer end of the basilar

[1] Sensations of Love.

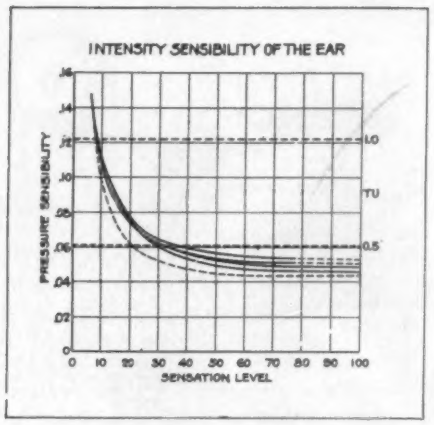


FIG. 4

membrane is free from other structures, and is highly specialized. It contains more than 3,000 fibres lying side by side and embedded in a homogeneous ground structure of different nature. These fibres are connected with the organ of corti which in turn is connected to the auditory nerve.

A few dimensions of the various parts of the ear may be of interest.[2] The ear canal is from 2.1 to 2.6 cm. long, has a volume of 1 cm.^{2} and an area at opening of 0.33 to 0.50 cm.^{2} The drum skin has a vertical diameter of 0.85 cm., a horizontal diameter of 1.0 cm. and an area of 0.65 cm.^{2} The hammer is from 0.8 to 0.9 cm. long and weighs 23 mg. The anvil weighs 25 mg. and the stirrup 3 mg. The oval window has a long diameter of 0.25 cm. and a short diameter of 0.12 cm. The basilar membrane is about 31 mm. long, 0.2 mm. wide at the oval window end and 0.36 mm. wide at the helicotrema end.

From the construction of the ear it can be seen that its various parts are so articulated as to form a very complex mechanically coupled system having distributed mass, resistance and compliance. Such a system is analogous to an electrical system having distributed inductance, resistance and capacity. Within limits, therefore, we may represent the ear mechanism by an electrical system, the limits being the lack of knowledge concerning some of the ear constants. Fig. 9 shows such a representation. The air in the ear canal, with its mass, radiation and friction resistance and compliance in series, is transformer coupled to the drum skin. The drum skin with its series mass, resistance and compliance is capacity coupled to the hammer, the hammer to the anvil, and the anvil to the stirrup with the attached membrane which closes the oval window. The system of the middle ear is transformer coupled to the liquid in the scala vestibuli with its series mass and resistance. The liquid in the scala vestibuli is transformer coupled to the lamina spiralis with attached basilar membrane, this in turn is transformer coupled to the liquid in the scala tympani, which is finally transformer coupled to the membrane closing the round window. Since different portions of the liquid in the scala vestibuli are put in motion by different frequencies, the masses in the scala vestibuli, lamina spiralis, and scala tympani are represented as variable. Side transformer coupled to the drum skin and stirrup is the air in the drum space, to which is transformer coupled the mastoid chambers. Side coupled to the liquid in the scala vestibuli are the three semicircular canals, only one of which is represented in the diagram.

[2] Fletcher, Bell System, *Tech. Jour.*, July 1925.

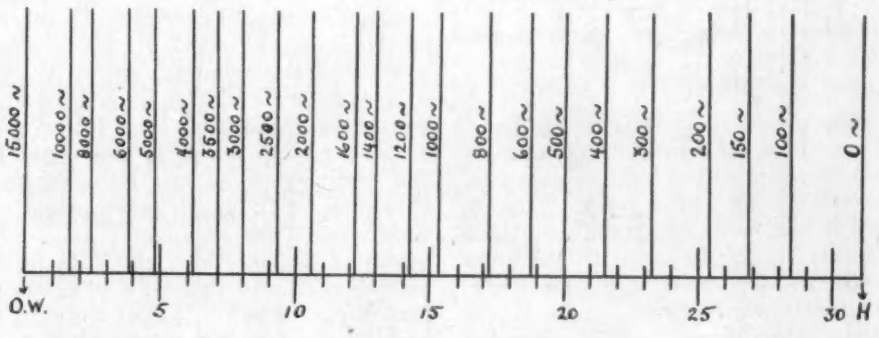


FIG. 9

Sensation of Hearing

There are several facts in connection with the sensation of hearing which are almost self-evident.

1. The ear senses and differentiates pure tones by means of the two properties pitch and loudness.

2. The ear does not ordinarily appreciate phase differences, except in the binaural case where both ears are used for locating the direction of a source of sound.

3. Two tones, having a sufficient frequency interval, sounded together, are sensed as two tones. They would not be sensed as a tone having an intermediate frequency.

4. There is a definite frequency difference that can just be sensed.

5. There are upper and lower limits of frequency above and below which there is no auditory sensation.

6. There is a definite intensity difference that can just be sensed.

7. There is a minimum intensity below which there is no sensation.

8. Some tones may be masked by others. In general a high frequency tone can be completely masked by an intense lower tone, but an intense high frequency tone cannot completely mask a weaker lower frequency tone.

The advent of the vacuum tube, the thermophone,[3] and the condenser transmitter[4] has made possible accurate measurements in audition. The three electrode vacuum tube, with attenuator, is capable of producing an oscillating electric current of any desired frequency and intensity. This electric oscillation is transformed to sound oscillation through the condenser transmitter into the thermophone. It is possible to calculate the acoustic output of the latter in terms of the electrical energy input, so that it is possible to calculate the pressure variation produced in the ear canal when a tone is being sensed. Such a combination of apparatus is called an Audiometer.[5] By means of it, the absolute sensitivity of normal and abnormal ears can be measured. Fig. 3 shows an intensity frequency curve for the average sensitivity of approximately 100 supposedly normal ears. The full curve shows average values, the ones on either side of it extremes from the mean. The ordinates give the amplitude of the r.m.s. pressure in the ear canal measured in transmission units or dynes per cm.^{2}, that is, just sufficient to cause an auditory sensation. The abscissae give the frequency of the tone perceived. In the important part of the speech range, *viz.* from 500 to 5,000 cycles, it requires about 0.001 dyne per cm.^{2}, or about 1 billionth of an atmosphere pressure variation in the air in the ear canal to cause an auditory sensation, which shows the extreme sensitiveness of the hearing mechanism. The lower curve represents what may be called the threshold of hearing. If the intensity

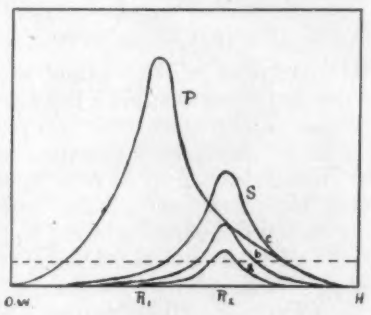


FIG. 6

[3] Arnold and Crandall, *Phys. Rev.*, July 1917.
[4] Wente, *Phys. Rev.*, July 1922.
[5] Fowler and Wegel, Trans. Am. Laryng. Rhin. and Otol. Soc., 1922.

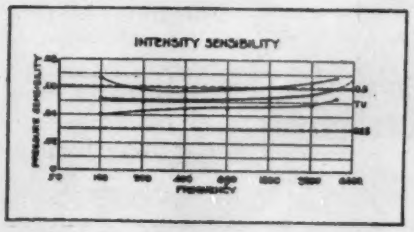


FIG. 7

level be gradually raised a value will ultimately be reached when the ear experiences a sensation of feeling(pain). Experiments have shown that the intensity for this sensation is approximately constant for various individual ears and the results can be duplicated as accurately as those for minimum intensity values. The upper curve then represents what may be called the threshold of feeling, and the area included by the two curves may be called the auditory tone-sensation area.

It is evident from Fig. 3 that the upper and lower frequency limits will depend on the pressure level or intensity (r.m.s. of pressure variation). For example, if the pressure level is 0.01 dyne per cm.^{2}, the frequency limits would be 200 to 13,000 cycles; if the pressure level were 0.1 dyne per cm.^{2}, the frequency limits would be 80 to 16,000 cycles, etc. The extreme frequency limits would be determined by the intersection points of the threshold of audibility and the threshold of feeling curves, which, for the curves shown are about 20 to 24,000 cycles.

Each point in the auditory sensation area represents a pure tone, that is, one of a definite frequency and intensity. It would be of interest to determine the number of such pure tones that can be sensed by the normal ear. To do this, it would be necessary to determine the sensitivity of the ear for small differences in frequency, and intensity. Knudsen[6] has made both of these determinations. In Fig. 4 each ordinate shows the fractional change in intensity which is just perceptible. This is called the pressure sensibility or Fechner ratio. The abscissæ are equal to ten times the log of ratio of intensities,

[6] *Phys. Review*, January 1923.

the zero corresponding to the intensity at threshold audibility. The four solid curves are for frequencies of 400, 1000, 2000 and 4000 cycles for the same ear. The dotted curve is for another ear at 1000 cycles. It will be noticed that the Fechner ratio becomes constant after an intensity of 10^4 times the threshold intensity has been reached. Its value is about 0.05. Fig. 7 (shown above) shows the Fechner ratio to be nearly constant for all frequencies. These curves are average values for several ears, the middle one being the average of all. Fig. 10 (upper right) shows the results of frequency sensibility. The ordinates give the fractional change in frequency that is just perceptible and the abscissæ are frequencies. For frequencies above 400 cycles, this fractional change is constant, having a value of about 0.003. This is about

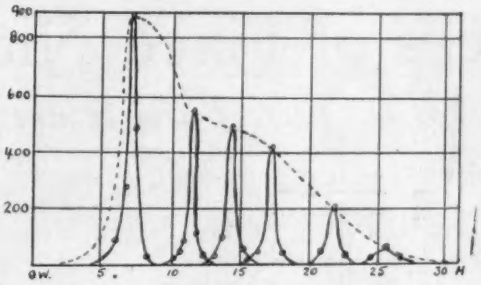


FIG. 8

one-twentieth of a tone on the tempered scale, and since there are twelve such tones in an octave, the ear can detect about 240 tones in an octave which are sensed as being different in frequency.

If, then, ordinates corresponding to the smallest detectable intensity, and abscissæ corresponding to the smallest detectable frequency be drawn, a rectangle will be formed, which may be considered as bounding a single pure tone. The number of such rectangles included in the sensation area, will then correspond to the number of pure tones which can be perceived as being different in intensity and frequency. Calculation gives 324,000 such tones.

If there are so many pure tones per-

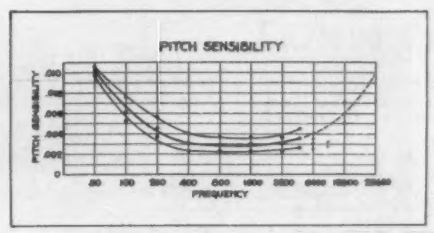


FIG. 10

ceptible, the question arises as to the number of complex tones that can be sensed by the ear. At first, it might seem that this number would be represented by all possible combinations of 324,000 pure tones. Practically, the number would doubtless be much smaller, because many of these tones would sound alike (this is particularly true for tones separated by an octave) and also because many of the louder tones would mask many of the weaker ones.

By obtaining the proper audiograms, abnormal hearing may be tested.[7] Scientifically, deafness may be defined as the per cent of the total number of pure tones sensed by a normal ear, that can be sensed by the abnormal ear. Since the number of pure tones corresponding to any region is proportional to the area of that region, the per cent hearing can be taken as the fractional part of the normal auditory sensation area in which tones can be sensed by the abnormal ear.

Helmholtz was the first to propose a theory to explain the hearing sensation. In this theory, the fibers in the organ of corti, or as later proposed, in the basilar membrane, act like sharply tuned resonators, each being stimulated by a tone of single frequency. This theory seems now to be untenable, since there are not enough fibres to correspond to the number of pure tones capable of being sensed, and also, due to the close proximity of these fibres, the motion of each must be affected by the reactions of its neighbors. We would have therefore forced vibrations in the fibres on either side of the reso-

[7] Fletcher, Trans. of the Coll. of Phys. of Phil., 1923.

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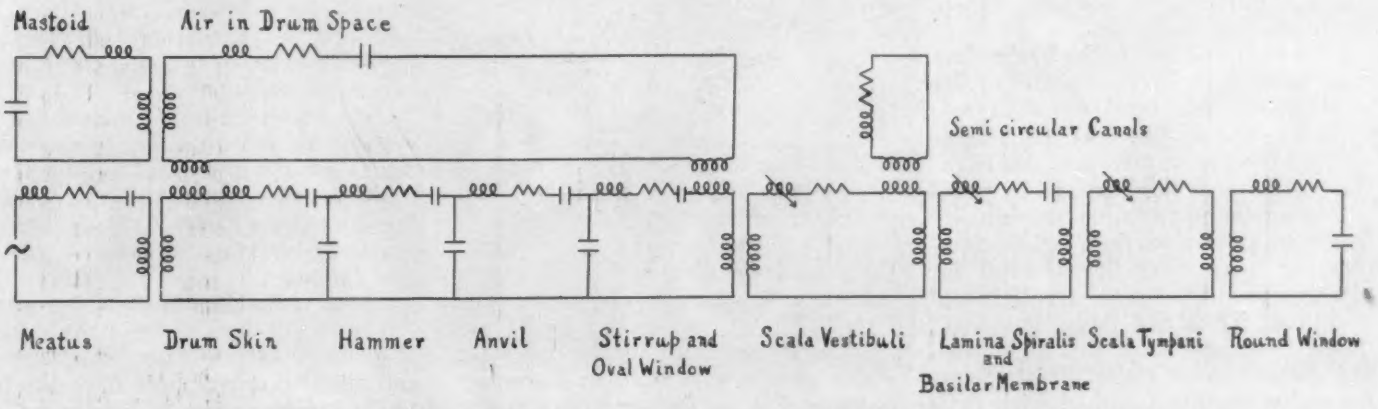
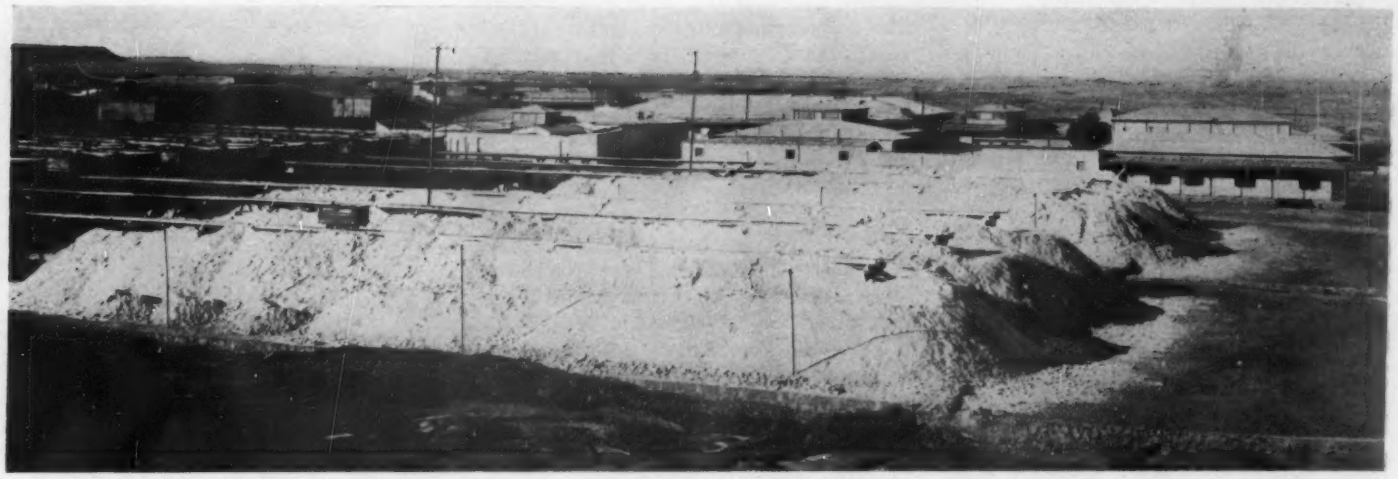


FIG. 9. A diagram of the electrical system analogous to complex mechanical system of the ear



ABSENCE OF RAIN MAKES OUTDOOR STORAGE POSSIBLE
Thousands of tons of highly soluble nitrate of soda would be lost from these storage piles should it rain for a few hours

Sources of Fixed Nitrogen

An economic discussion of the present and future supply of fixed nitrogen

By ARTHUR E. WELLS, '06
Professor of Non-Ferrous Metallurgy
Harvard Engineering School

FIXED nitrogen, being an essential element in fertilizer materials and in several important industries, is a commodity of great importance. The problem of the supply of nitrogen products is an international one. With few exceptions most of the thickly populated countries of the world are buyers of some forms of fixed nitrogen in the world market, and until recently any country which has produced more than that amount necessary to meet the domestic demand has found a ready foreign market.

Organic nitrogen products constitute a consequential source of supply, and one that is increasing in yearly production, yet they are decreasing in availability as sources of nitrogen due to the fact that more and more of them are being used for stock feed, thus commanding a higher price than can be justified for fertilizer purposes. The world is thus dependent almost entirely on sources of fixed inorganic nitrogen for fertilizer and industrial uses in general, and particularly in order to meet the increasing demands.

Prior to the advent of the by-product coke oven, with its production of by-product ammonia, nitrate of soda from Chile was the world's only dependable source of inorganic nitrogen. When, at the beginning of this century, by-product ammonia and ammonium sulphate began to appear on the market in increasing quantities, the demand for nitrogen products for the fertilizer and chemical industries also increased. These by-products, as well as increasing quantities of Chile nitrate, were generally readily absorbed with little or no serious competition between the two sources. The prices of nitrogen in the by-product ammonia and ammonium sulphate products were controlled generally by the price of nitrogen in Chile nitrate.

TABLE A
CONSUMPTION AND SOURCES OF INORGANIC NITROGEN

Source	*Tons of Fixed Nitrogen* 1913	1920	1926
Chile nitrate	450,000	420,000	350,000
Ammonia and ammonium sulphate from coking of coal	300,000	350,000	340,000
Ammonia and products from ammonia derived by the direct ammonia synthesis process (Haber, Claude and Casale)	7,000	220,000	450,000
Cyanamide and products from cyanamide	41,000	100,000	100,000
Products of arc process	12,000	10,000	30,000
	810,000	1,100,000	1,250,000

TABLE B

Source	*Tons Fixed Nitrogen per Year*	
By-product ammonia	450,000	output depending on demand for coke
Synthetic ammonia (Haber Process or modification thereof)	520,000	increasing at rate of 10% per year.
Cyanamide	250,000	about 40% in use
Arc process	30,000	decreasing
Total (not including Chile nitrate)	1,250,000	

The commercial manufacture of synthetic nitrogen products from atmospheric nitrogen dates from the beginning of the present century with the establishment of the arc process in Norway and afterwards in Austria and Italy. In 1906, calcium cyanamide was first produced, and in the next ten years, plants were built in Germany, Norway, France, Switzerland, Canada, Austria, Japan and Sweden. The Haber process for the direct synthesis of ammonia was first brought to a successful commercial stage in Germany in 1913, where two large plants were built during the war.

The increase in the world's demand for inorganic nitrogen between the years 1913 and 1926, with the increases in the production of synthetic products during that period is shown in Table A.

The present day capacity to produce nitrogen products is estimated to be approximately as shown in Table B. The actual total capacity to produce Chile nitrate is probably between 400,000 and 500,000 tons of nitrogen equivalent. Probably over 350,000 tons can be produced profitably at present prices with the present rate of export tax levied on the nitrate by the Chilean government.

It is evident from the above statistics that the total capacity to produce, of all producers of fixed inorganic nitrogen products, is greatly in excess of the present day demand, and there is, therefore, a pronounced competitive condition existing between the several sources of supply.

In this paper will be outlined briefly the factors affecting the possible increase or reduction in output from these sources under the competitive conditions which now exist and which will probably continue to exist in the near future.

Let us consider first the fixed nitrogen products derived from the coking of coal. The production of ammonia and ammonium sulphate from the by-product coke ovens is dependent al-

most entirely upon the demand for coke and this in turn is dependent upon the demand for iron and steel products.

The rapid increase in the capacity of and output from by-product coke ovens in the United States in the first twenty-five years of this century was due not only to the increase in the consumption of pig iron but also to the extensive substitution of by-product coking for coking in the beehive ovens. In 1900, the production of by-product coke was about 1,000,000 tons, or less than 5 per cent of the total coke production in the United States, with an annual "by-product" production of ammonia products, "by-products" expressed as fixed nitrogen, of less than 2,000 tons. In 1926, about 45,000,000 tons or 80 per cent of the total coke production was from the by-product coke oven, with a production of ammonia products, expressed as fixed nitrogen of nearly 150,000 tons. In addition, the coal gas plants produced approximately 6,000 tons of fixed nitrogen.

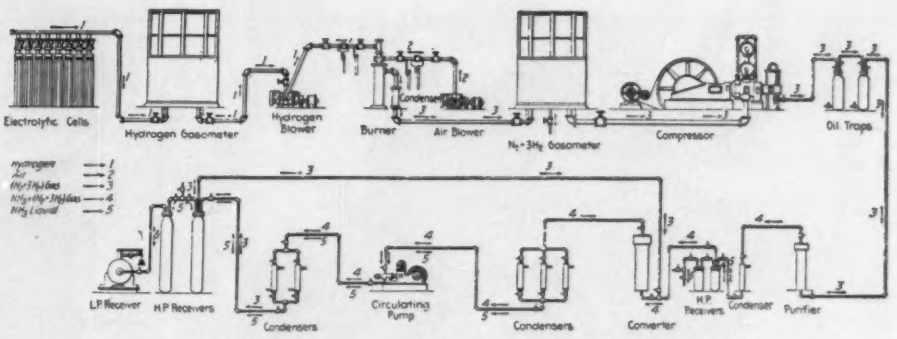
It is not expected that the production of by-product coke and of by-product nitrogen will continue to increase in the next twenty years at the same rate as they have in the past. By-product coke production probably will not altogether supersede coke oven production. It will probably be desirable and economical to have a certain percentage of the total capacity in the form of beehive ovens, the percentage in by-product ovens being approximately equal to the average steady demand for coke, with the beehive ovens, since they represent a much smaller capital investment per unit of coke product, being available to meet the fluctuating peak demands.

On the assumption that the demand for pig iron in this country will increase at the rate of 1,000,000 tons per year during the next ten years, there will be an increasing production rate of about 1,000,000 tons of coke per year. Assuming that three-fourths of this will be from by-product coke ovens, a (normal) average increase in fixed nitrogen from by-product ovens will be about 2,500 tons per year. Curtis* estimated that the increase over a ten-year period in the production of fixed nitrogen in the United States owing to increases in the demand for coke and in the manufacture of gas might be about 80,000 tons, or 8,000 tons per year.

It is estimated that the total average increase in production of by-product nitrogen in all countries may be at least 10,000 tons per year, so that by 1937 the production of by-product fixed nitrogen may be as much as 550,000 tons.

This fixed nitrogen will find an outlet almost regardless of competition, as it is essentially a by-product, obtained at relatively low cost, and must be disposed of even if at a low price.

* Nitrogen Survey-Trade Information Bulletin No. 226, May 5, 1924, Commerce Reports.



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FLOW SHEET FOR SYNTHETIC AMMONIA PLANT

"CALICHEROS" WORKING IN AN OPEN MINE

As a source of fixed nitrogen products, the arc process is becoming less and less important. In this process, the nitrogen and oxygen in the air are directly burned to nitric oxide under the influence of the electric arc. The resulting product is then absorbed in water in large granite towers, and the nitric acid produced is either shipped as such or used to make calcium nitrate.

Due to the excessive power requirements (65,000 k. w. hrs. per ton of fixed nitrogen), the extensive and costly character of the absorption plant, and the lack of expectancy of any radical changes in the economies of the arc process, it may be stated that there is very little likelihood of any increase in output of fixed nitrogen from this source. In fact, at the present time, the large Norwegian arc process plants with their cheap hydroelectric power resources are being gradually converted to a modification of the direct ammonia synthesis or Haber process. It is interesting to note that the first step in this direction was made with the engineering direction of an American engineering company — the Nitrogen Engineering Corporation of New York.

The present day capacity of the cyanamide plants is over twice the present output. A large part of this capacity was installed and operated in the war emergency. The raw materials required are calcium carbonate, anthracite coal or coke, and nitrogen from the air. Although it requires only about one fifth of the power required by the arc process, per unit of fixed nitrogen, nevertheless this too must be very cheap power for successful operation under peace time conditions.

The primary product of the process is calcium cyanamide which is a rather dusty, disagreeable and difficult product to handle unless specially treated. It has not found favor with American fertilizer manufacturers in the manufacture of mixed fertilizer and has been used to only a limited extent in Europe. The world's annual consumption of cyanamide itself has never been greater

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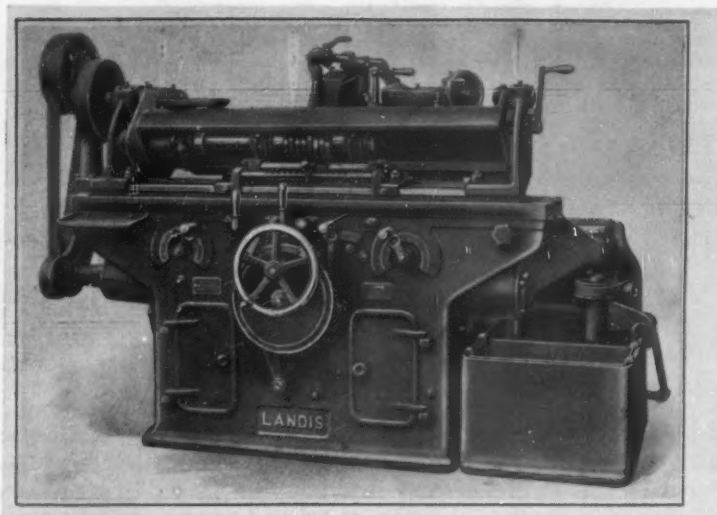
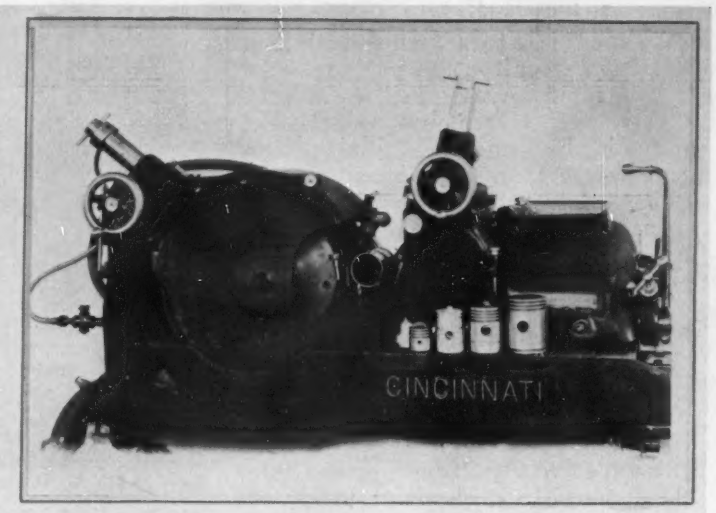
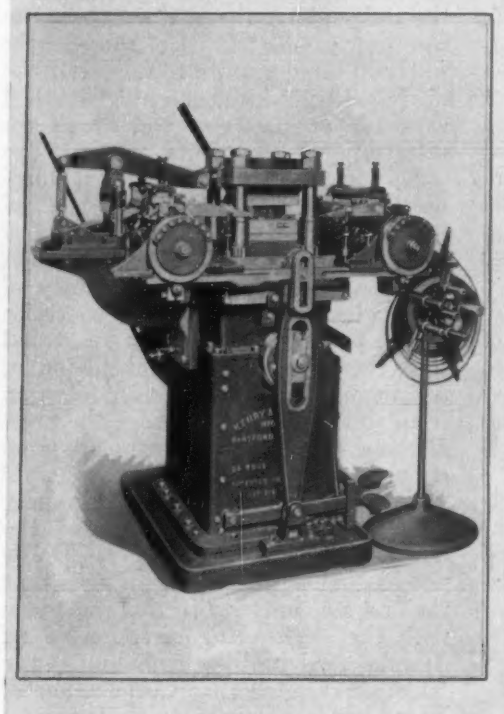
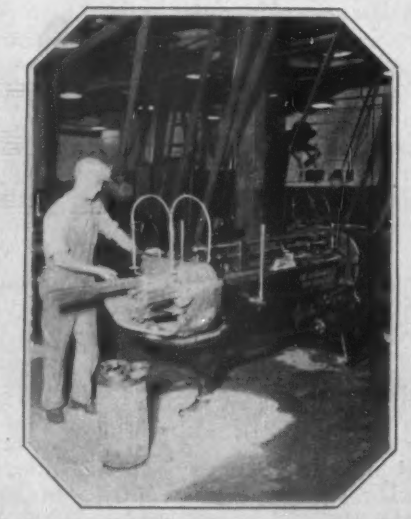
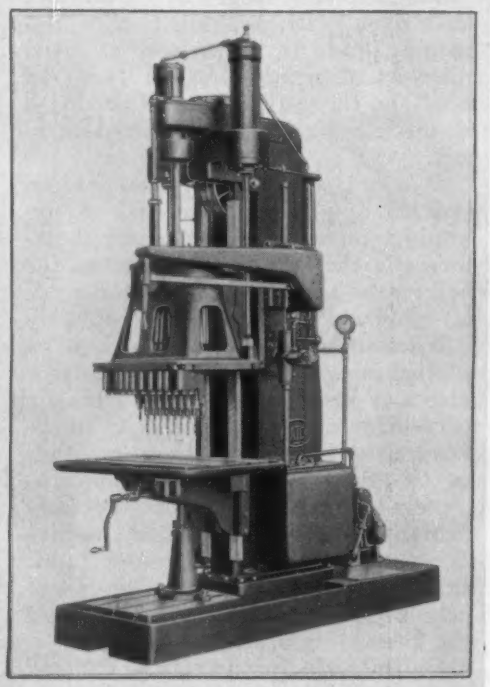
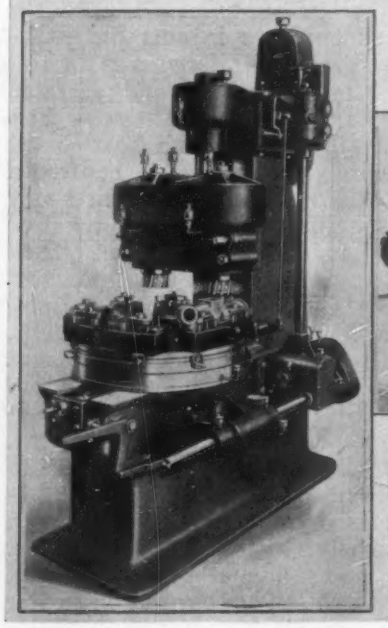


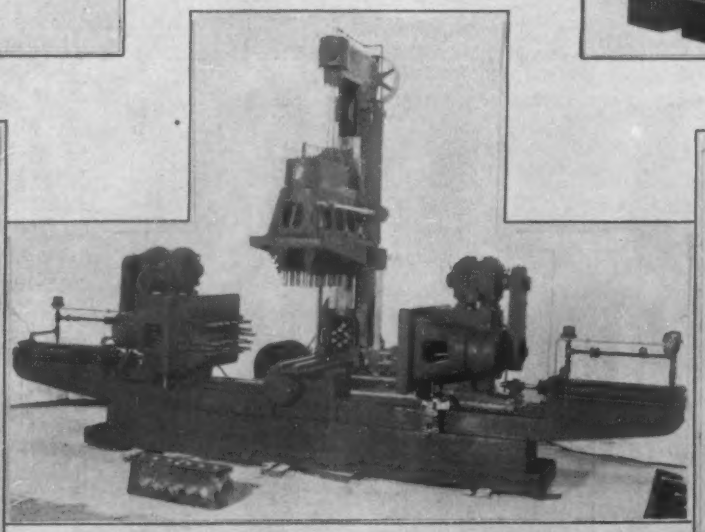


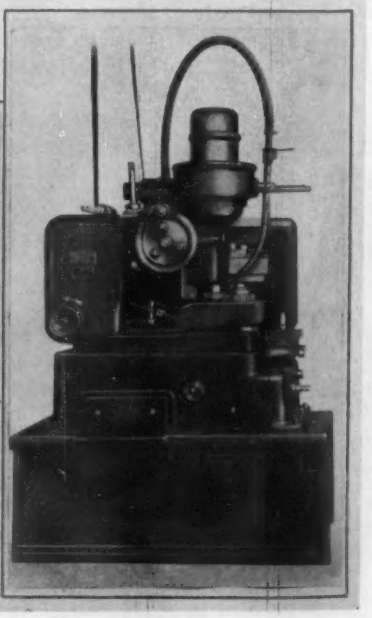












SEMI-AUTOMATIC METAL WORKING MACHINES

(*Top left*) The Landis Camshaft Grinding machine. (*Top right*) Grinding automotive pistons without mounting on center. (*Middle left*) Wright Dieing machine. (*Center*) Double Broaching machine for cutting keyways. (*Middle right*) Natco Multiple Drilling machine. (*Lower left*) Continuous milling machine. (*Lower center*) Drilling sixty-seven holes in one operation. The Fox Four-Way Multiple Drill press. (*Lower right*) High Speed Gear Shaper.

Master Tools of Production

An illustrated review of machines used in large scale production

By ROBERT H. SMITH
Associate Professor of Machine Construction
Massachusetts Institute of Technology

A FEW years ago the Massachusetts Institute of Technology introduced into its schedule of studies courses in General Production which develop practical ideals and create an interest in industrial progress. Interest in cost reduction is becoming universal, and is fundamental to successful manufacturing. Increased production, or lowering the cost of manufacture is the most promising means of earning profits and continuing the business.

Master production machines have gone a long way in solving problems of this nature. These machines represent automatic, duplex, multiple and single-purpose machines, the most wonderful machines of production the human mind has yet conceived. Progress toward present civilization shows clearly that it has been due largely to our ability to design and build industrial machines.

It is through machinery that we are surrounded with the modern comforts of life, and mental and moral development. Our hope of progressing to a greater civilization lies in mass education and mass production.

LANDIS CAMSHAFT GRINDING MACHINE

Camshafts and crankshafts used on automobiles, airplanes and other combustion motors, are finished by grinding on special hydraulic production machines.

In the Landis Camshaft Grinding Machine the camshaft is mounted upon centers and is supported between the cams by adjustable rests.

A master cam governs the form of the cam reproduced. This master cam is generated direct from the cams on a model camshaft furnished by the purchaser or made to specifications.

If a number of these master cams are placed upon a mandrel in the right relation to each other, they may be used to reproduce camshafts in quantity.

THE CINCINNATI CENTERLESS GRINDING MACHINE

The Centerless Grinder represents a radical departure and a revolutionary improvement in machines and methods of producing work of circular form.

In the past it has been customary to drill and countersink the ends of the work before grinding. Centers are not required in this process of grinding.

As distinguished from center types of machines, the Centerless machine consists of a high-speed grinding wheel and an opposed slowly moving regulating wheel, forming a grinding throat. A work rest suitably supports the work in this throat and the several parts are relatively adjustable for differing sizes and varieties of work.

The grinding wheel serves solely for grinding purposes, while the regulating wheel controls the speed of the work pieces and the feeding movement. The feed of work through machine without change of speed is made possible by the angular adjustment of the regulating wheel. Combined with an automatic hopper feed this grinder functions automatically.

There are two primary methods of grinding. One is the "through feed" suitable for straight cylindrical work; the other is the "infeed" method which introduces the work into the grinding machine throat laterally.

Centerless grinding is an economical method of finishing cylindrical parts, such as piston, wrist pins, rollers, bearings, valve lifter roller pins, king bolts, studs, rods, tubes, etc.

WRIGHT DIEING MACHINE

Punch presses have been in common use since the time the engineer was able to employ sheet metal as a basis of manufacture. For the past hundred years there has been but little change in the type or construction of presses for the use of blanking, forming, drawing, embossing, etc., of sheet metal.

This machine constitutes a departure from the usual style of press in that the automatic features are combined with the machine and that safety features have been incorporated in its design.

As shown in illustration the machine includes a frame of which the upper part forms a table or support for a bolster plate on which the dies are attached.

The material used by the machine is a roll of ribbon metal fed automatically from a reel.

This machine will often increase press production from 20 to 50 per cent. Speed of production is between 11,000 and 12,000 finished pieces per hour.

LAPOINTE DOUBLE BROACHING MACHINE

When keyways are to be cut in considerable numbers, no other method can compare with broaching in speed, accuracy or economy.

An example of this kind of broaching is found on Ford automobile hubs where keyways ¼ x ⅛ inch and 3¼ inches long in a tapered hole are cut at the rate of 100 an hour.

Work with similar opposite faces can be broached two sides at a stroke.

A broaching machine is not confined to one type of work. It is only a question of the proper broach. The cut may be any size or pattern from a keyway to a multiple radial spline, a plain bearing or an internal ratchet, all accurate to the thousandths of an inch. It may be the diameter of a coarse knitting needle, or as thick as a man's arm. There is no limit to the size of a round broach that may be used, except the power of the machine to pull it.

In the duplex broaching machine shown in this illustration one piece of work can be placed in position while the other is being broached thus forming a nearly continuous flow of production.

NATCO MULTIPLE DRILLING MACHINE

This machine drills, reams, taps and spot faces all the holes in the sides of frames of machines in a single operation.

The drill sockets driven through universal joints can be located in any position desired for any given location so that all the holes can be drilled, reamed, or tapped in the same length of time that is required to drill a single hole.

NEWTON CONTINUOUS MILLING MACHINE

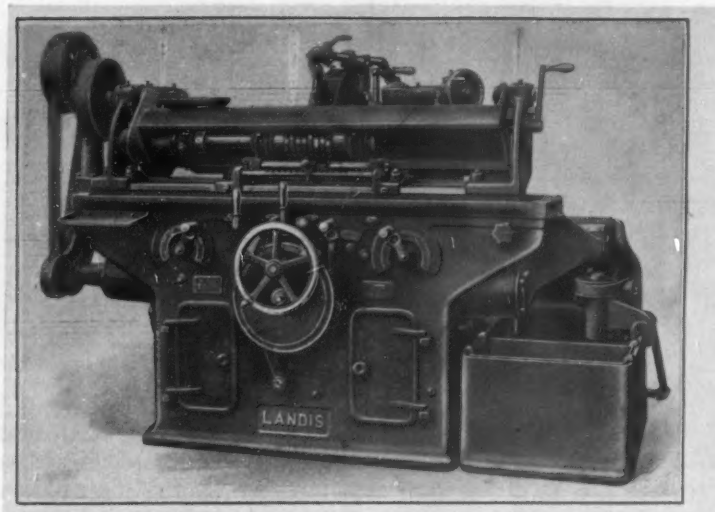
Work requiring flat finished surfaces, such as the gasket surfaces of automobile manifolds, cylinder heads, cylinder blocks, electric iron bases, pump cases, etc., can be rapidly rough and finish milled at the same setting in this machine.

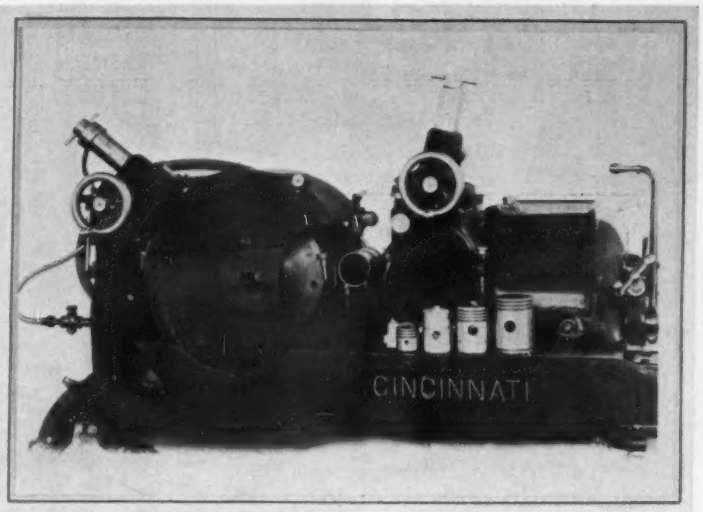
The work is fastened in the several fixtures upon the revolving table and passed under the roughing and finishing cutters. As the pieces are milled the fixtures are unloaded and loaded again without stopping the machine.

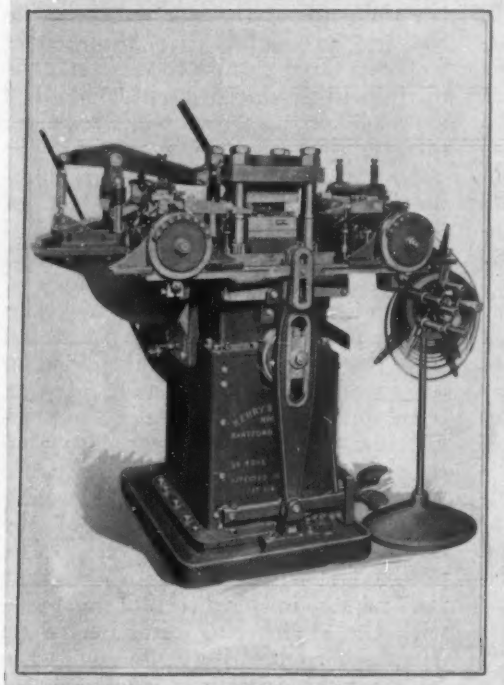
Cylinder heads can be finished at the rate of about two hundred and twenty-five in eight hours.

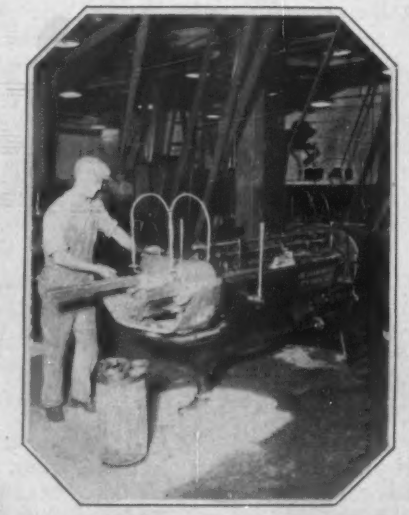
FOX FOUR-WAY SEMI-AUTOMATIC DRILLING MACHINE

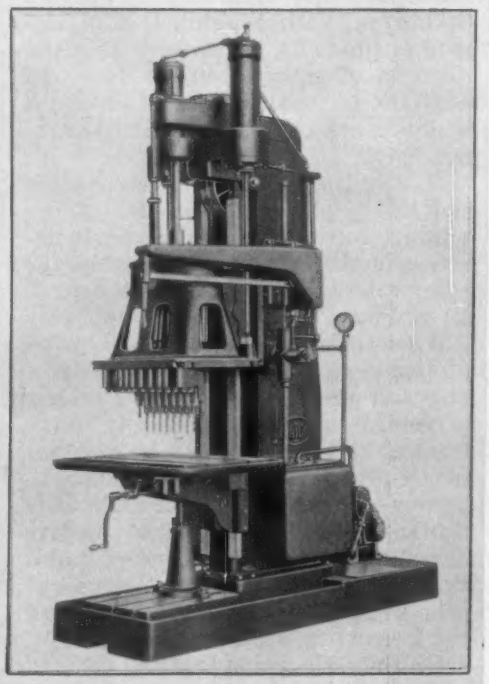
This four-way semi-automatic machine is used for drilling four sides of an automobile cylinder block in one operation for a well-known six-cylinder engine. It produces one complete block or 54 holes per minute.

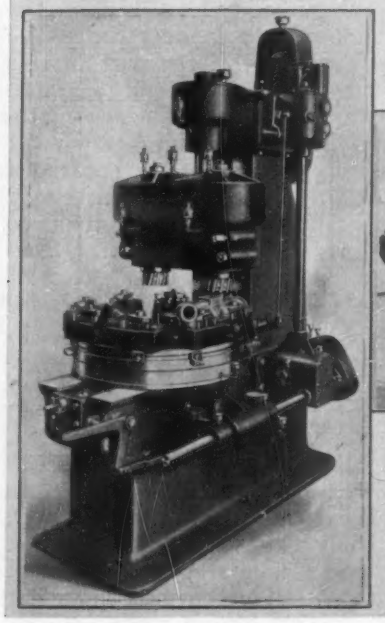


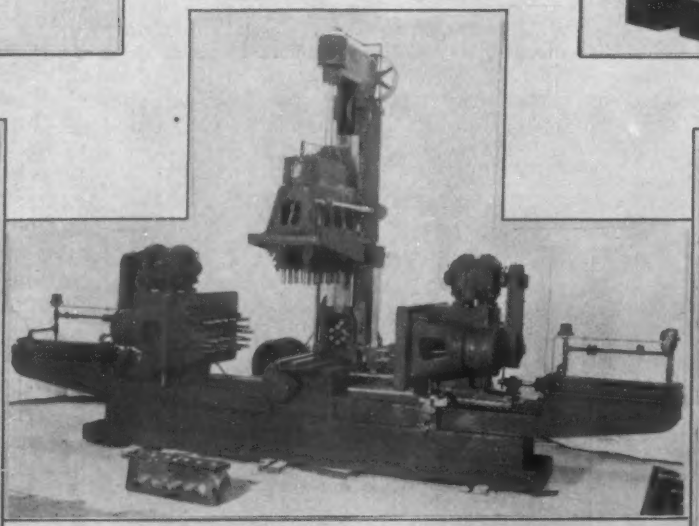


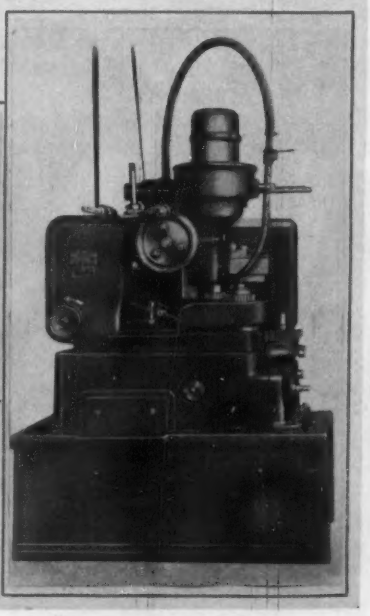












SEMI-AUTOMATIC METAL WORKING MACHINES

(*Top left*) The Landis Camshaft Grinding machine. (*Top right*) Grinding automotive pistons without mounting on center. (*Middle left*) Wright Dieing machine. (*Center*) Double Broaching machine for cutting keyways. (*Middle right*) Natco Multiple Drilling machine. (*Lower left*) Continuous milling machine. (*Lower center*) Drilling sixty-seven holes in one operation. The Fox Four-Way Multiple Drill press. (*Lower right*) High Speed Gear Shaper.

Master Tools of Production

An illustrated review of machines used in large scale production

By ROBERT H. SMITH
Associate Professor of Machine Construction
Massachusetts Institute of Technology

A FEW years ago the Massachusetts Institute of Technology introduced into its schedule of studies courses in General Production which develop practical ideals and create an interest in industrial progress. Interest in cost reduction is becoming universal, and is fundamental to successful manufacturing. Increased production, or lowering the cost of manufacture is the most promising means of earning profits and continuing the business.

Master production machines have gone a long way in solving problems of this nature. These machines represent automatic, duplex, multiple and single-purpose machines, the most wonderful machines of production the human mind has yet conceived. Progress toward present civilization shows clearly that it has been due largely to our ability to design and build industrial machines.

It is through machinery that we are surrounded with the modern comforts of life, and mental and moral development. Our hope of progressing to a greater civilization lies in mass education and mass production.

LANDIS CAMSHAFT GRINDING MACHINE

Camshafts and crankshafts used on automobiles, airplanes and other combustion motors, are finished by grinding on special hydraulic production machines.

In the Landis Camshaft Grinding Machine the camshaft is mounted upon centers and is supported between the cams by adjustable rests.

A master cam governs the form of the cam reproduced. This master cam is generated direct from the cams on a model camshaft furnished by the purchaser or made to specifications.

If a number of these master cams are placed upon a mandrel in the right relation to each other, they may be used to reproduce camshafts in quantity.

THE CINCINNATI CENTERLESS GRINDING MACHINE

The Centerless Grinder represents a radical departure and a revolutionary improvement in machines and methods of producing work of circular form.

In the past it has been customary to drill and countersink the ends of the work before grinding. Centers are not required in this process of grinding.

As distinguished from center types of machines, the Centerless machine consists of a high-speed grinding wheel and an opposed slowly moving regulating wheel, forming a grinding throat. A work rest suitably supports the work in this throat and the several parts are relatively adjustable for differing sizes and varieties of work.

The grinding wheel serves solely for grinding purposes, while the regulating wheel controls the speed of the work pieces and the feeding movement. The feed of work through machine without change of speed is made possible by the angular adjustment of the regulating wheel. Combined with an automatic hopper feed this grinder functions automatically.

There are two primary methods of grinding. One is the "through feed" suitable for straight cylindrical work; the other is the "infeed" method which introduces the work into the grinding machine throat laterally.

Centerless grinding is an economical method of finishing cylindrical parts, such as piston, wrist pins, rollers, bearings, valve lifter roller pins, king bolts, studs, rods, tubes, etc.

WRIGHT DIEING MACHINE

Punch presses have been in common use since the time the engineer was able to employ sheet metal as a basis of manufacture. For the past hundred years there has been but little change in the type or construction of presses for the use of blanking, forming, drawing, embossing, etc., of sheet metal.

This machine constitutes a departure from the usual style of press in that the automatic features are combined with the machine and that safety features have been incorporated in its design.

As shown in illustration the machine includes a frame of which the upper part forms a table or support for a bolster plate on which the dies are attached.

The material used by the machine is a roll of ribbon metal fed automatically from a reel.

This machine will often increase press production from 20 to 50 per cent. Speed of production is between 11,000 and 12,000 finished pieces per hour.

LAPOINTE DOUBLE BROACHING MACHINE

When keyways are to be cut in considerable numbers, no other method can compare with broaching in speed, accuracy or economy.

An example of this kind of broaching is found on Ford automobile hubs where keyways ¼ x ⅛ inch and 3¼ inches long in a tapered hole are cut at the rate of 100 an hour.

Work with similar opposite faces can be broached two sides at a stroke.

A broaching machine is not confined to one type of work. It is only a question of the proper broach. The cut may be any size or pattern from a keyway to a multiple radial spline, a plain bearing or an internal ratchet, all accurate to the thousandths of an inch. It may be the diameter of a coarse knitting needle, or as thick as a man's arm. There is no limit to the size of a round broach that may be used, except the power of the machine to pull it.

In the duplex broaching machine shown in this illustration one piece of work can be placed in position while the other is being broached thus forming a nearly continuous flow of production.

NATCO MULTIPLE DRILLING MACHINE

This machine drills, reams, taps and spot faces all the holes in the sides of frames of machines in a single operation.

The drill sockets driven through universal joints can be located in any position desired for any given location so that all the holes can be drilled, reamed, or tapped in the same length of time that is required to drill a single hole.

NEWTON CONTINUOUS MILLING MACHINE

Work requiring flat finished surfaces, such as the gasket surfaces of automobile manifolds, cylinder heads, cylinder blocks, electric iron bases, pump cases, etc., can be rapidly rough and finish milled at the same setting in this machine.

The work is fastened in the several fixtures upon the revolving table and passed under the roughing and finishing cutters. As the pieces are milled the fixtures are unloaded and loaded again without stopping the machine.

Cylinder heads can be finished at the rate of about two hundred and twenty-five in eight hours.

FOX FOUR-WAY SEMI-AUTOMATIC DRILLING MACHINE

This four-way semi-automatic machine is used for drilling four sides of an automobile cylinder block in one operation for a well-known six-cylinder engine. It produces one complete block or 54 holes per minute.

Hydraulic cylinders having an automatic control throttle give rapid advance of heads to the drilling point and rapid return of heads to the starting point.

One movement of the lever at the front starts all spindles rotating and all heads feeding into the work at correct rates of speed. Reversing of the tapping spindles and of the head feeds is entirely automatic, yet the operator can reverse the machine at any time, or stop it, if necessary. When the heads have fed back clear of the work, the spindles stop rotating and the heads remain stationary.

THE FELLOWS HIGH SPEED GEAR SHAPER

This machine cuts spur, helical and internal gears with equal facility. It has a record for accuracy and speed of production working on the principle of the vertical shaper. It is quiet in operation and occupies a minimum of space.

The speed of production is such that automobile manufacturers use it for producing transmission gears in large quantities. It cuts one gear at a time or several gears arranged in a gang upon a mandrel; it represents the very latest product in machine design in that it is fully ball bearing equipped with all high speed bearings automatically lubricated.

The machine is simple in construction and easy to operate. One operator can easily care for several machines. The cutter is a gear itself which feeds its way into the blank to the proper depth while both cutter and blank are rotating, thereby generating a gear. It will cut several gears upon the same blank which are as close to each other as one-eighth of an inch. This is the only machine that will cut an internal gear that has teeth within one-eighth of an inch of the shoulder.

ACME MULTIPLE SPINDLE AUTOMATIC SCREW MACHINE

The manufacture of finished bolts, nuts, and countless small machine parts constitutes one of the best examples of quantity production that we have. Automatic screw machines are excellent types for this class of work.

The material used is bar stock of brass, aluminum, steel, fibre, etc. The daily output of screw machine companies is about 2,000,000 pieces.

The five spindles of the Acme Screw Machine carry five rods of stock. Ten tool positions are provided, one tool working from the side and one from the end on each of the five bars. The stop which gauges the feed does not occupy one of the tool positions. All tools work on the pieces at once.

For irregular work on the screw machine, such as milling, drilling, etc., from the side or end, there are standardized special attachments. Two tools with or without attachments are frequently used in combination in one of the ten positions, for unusual operations.

FAY AUTOMATIC PRODUCTION LATHE

The Fay Automatic Lathe is successfully solving production problems of an ever-increasing number of manufacturers.

This is an automatic metal-turning machine that has been developed to obtain intense production, in the most modern sense of the word, on turned work within its range.

Possessed with abundant power, exceptional rigidity, and remarkable accuracy, it is successfully operating today under exacting requirements on an extremely wide range of work.

The ease with which this machine may be changed from one kind of work to another has made it a highly profitable production machine.

The Fay Automatic Lathe is adapted to the machining of forgings, castings, or bars that may be held on centers, in a chuck, or supported on fixtures, and to the turning of work mounted on arbors.

INGERSOLL DRUM-TYPE CONTINUOUS MILLING MACHINE

One of the most important processes of production is that of continuous milling. Machines for continuous milling are provided with large rotating drums or tables to which eight or more large castings, such as automobile cylinder blocks, cylinder heads, or crankcases are clamped. These revolving drums carry fixtures by the roughing and finishing cutters in such a way that the work can be loaded and unloaded readily without stopping the machine. The drum travels at the rate of about one revolution every twelve minutes giving a finished casting every two minutes. It revolves continuously; the operator unloads a finished casting from the rear of the machine as the drum swings upward, replacing it with a rough casting, which is brought to and away from the machine on a conveyor.

BLISS POWER PRESS

Nothing has done more to revolutionize the construction of machinery and of the various things we use daily, than the art of stamping metal. This has come about by the use of power presses of various sizes.

The products of these machines range in size from second hands for watches to steel freight car ends.

These presses are capable of producing either singly or automatically almost everything in the line of metallic parts; some of the latest devices include the panels of automobile bodies. Nine advantages to be obtained by the use of these presses, are: absolute uniformity and decrease of weight from 25 to 75 per cent; no breakage; increased strength, smoother service, minimum of machining; 30 to 50 per cent saving in cost of painting and enameling.

The material is sheet metal fed into the press either by hand in sheets for large production, or from the coil of ribbon metal for the high production of the smaller parts.

LESTER DIE-CASTING MACHINE

Many machine parts are so intricate that the manufacturing costs would make them prohibitive if made in the regular way. Among these are vacuum cleaner parts, adding machine parts, cash register parts, automobile ignition parts, etc. When there is a demand for enough of these parts to pay for making the dies, as from one thousand to one hundred thousand, they may be made economically by the process of die casting.

This machine is made to take various forms of dies and almost any piece can be cast with equal facility. An alloy of a comparatively low melting point, or aluminum, is generally used. The molten metal is forced into the mould by air pressure and the machine is adapted to making practically all shapes of castings from aluminum and other white metal alloys. This process makes castings from the fraction of an ounce up to four pounds, with an area of about one square inch or a spread of 20 inches square, with accuracy and uniformity.

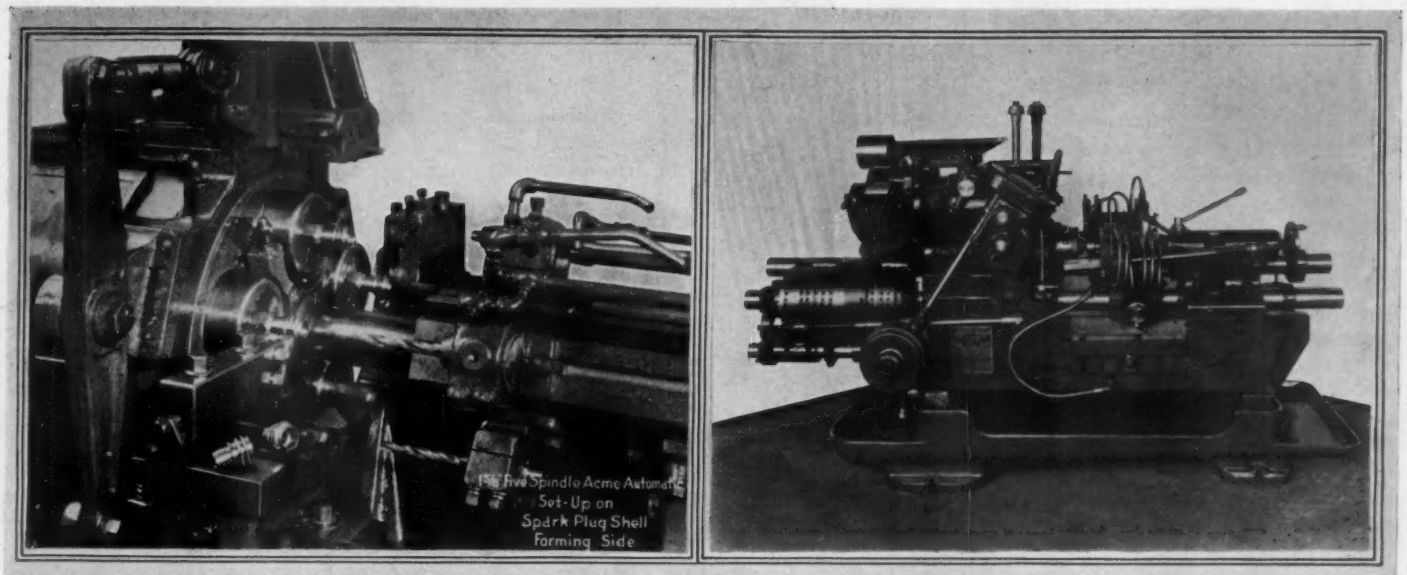
From 60 to 250 operations per hour are obtainable according to the shape of the casting. The number of castings produced at each operation depends on the number of cavities gated together in the mould which may be from one to sixty.

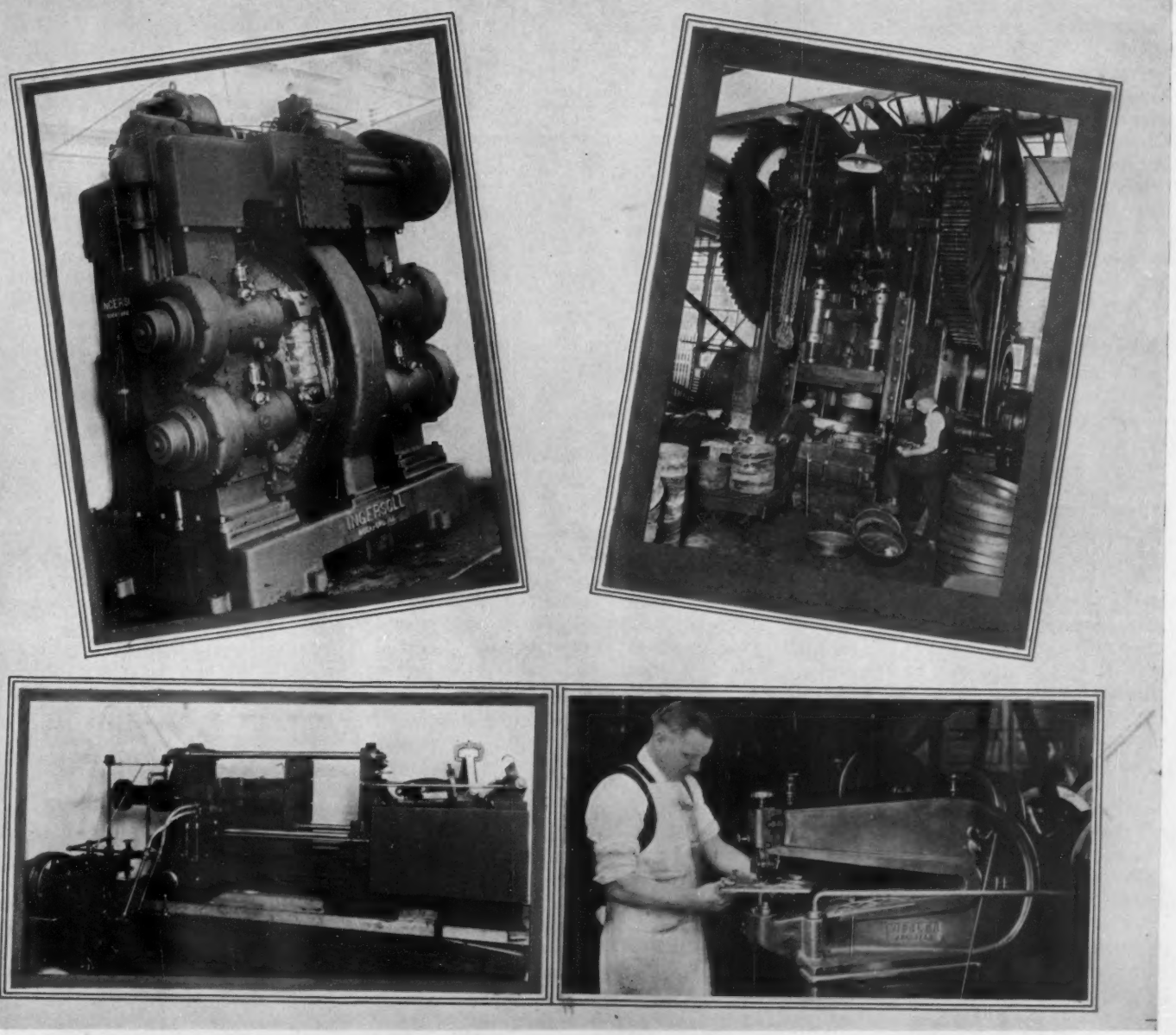
CAMPBELL NIBBLING MACHINE

This machine fills a gap which has long existed between the laborious hand or drilling methods and the speed and economy of the metal stamping press.

Where it is impracticable to make cutting dies to blank out stampings, and intricate parts in quantity are still wanted, the Campbell Nibbling Machine is saving countless manufacturers time and money and is assisting them

(*Continued on page 318*)





MAKING THE INEXPENSIVE MACHINING OF PARTS POSSIBLE

It is only with machines such as these that the ever-growing demand for accurately machined, inexpensively produced parts is met. (*Upper left*) Automatic machine for making the spark plugs. (*Upper right*) Fay Automatic Production Lathe. (*Middle left*) Continuous milling machine with automobile cylinder blocks mounted in the revolving work drum. (*Middle right*) Mechanically pressing brake drums from sheet steel. (*Lower left*) Lester Die-Casting machine. Small, intricate castings such as vacuum cleaner parts are cheaply manufactured, because the same mold can be used to make a great number of castings. (*Lower right*) Campbell Nibbling machine. Many parts for the famous Spirit of St. Louis were made by this machine.

Departmental Notes

DEPARTMENT OF CIVIL AND SANITARY ENGINEERING

THE Miami Conservancy District has recently entered into an agreement with the Institute for experimental work to be conducted in the Laboratory of Soil Mechanics under the general supervision of Dr. Charles Terzaghi, Associate Professor of Foundation Engineering, and under the specific direction of Glennon Gilboy, Research Associate in Foundation Engineering.

The purpose of this agreement is to secure and develop data which will define governing principles and advance the science of construction of hydraulic fill dams. As a result of this agreement, the Miami Conservancy District has selected a dam, the records of which are especially complete, as suitable for these experiments, and has sunk into the core a 4-foot diameter concrete lined shaft to a depth of 75 feet and one drillhole and has obtained samples of the core material. It is also securing samples from the borrow pits from which the core material was originally obtained. All these samples are being sent to the Institute for laboratory tests in the Soil Mechanics Laboratory.

In pursuance of this agreement, Mr. Gilboy has been actively engaged in this work for the past four months.

K. C. Reynolds, Instructor in Civil Engineering, who was granted the Freeman Traveling Fellowship offered by the Boston Society of Civil Engineers for study in the hydraulic laboratories of Europe, is located at the Technische Hochschule at Karlsruhe, where he is working under the direct supervision of Professor Rehbock, whose investigations of the problems of river flow have given him an international reputation. Morrough P. O'Brien, I, '25, who has received a similar fellowship from the American Society of Civil Engineers, is studying at the Technical University of Stockholm, and J. B. Drisko, I, '27, who holds a traveling fellowship from the Institute for similar study in Germany, is now located at the Technische Hochschule at Danzig.

Negotiations are under way with one of the prominent railroads in New England to establish a Coöperative Course in Railroad Operation under the direction of the Civil Engineering Department. This course will be along the same lines as the coöperative courses in Electrical Engineering established some time ago with the General Electric Company, the American Telephone Company and other similar organizations.

The coöperative investigation of subgrade materials inaugurated between the Institute and the United States Bureau of Public Roads in 1926 is being continued for another year. Under this agreement, the Government maintains a research assistant at the Institute, Arthur Casagrande, Diplom-Ing., Technische Hochschule in Vienna 1924, and has supplied a considerable amount of equipment to the Soil Mechanics Laboratory for conducting investigations.

The following new textbooks by members of the department have been published during the year: "Water Power Engineering," by Professor Barrows, and "Stream Gaging," by Mr. Liddell. The first of these covers the course in Water Power Engineering given at the Institute to students in the Hydro-electric Option. It includes the results hitherto unpublished of a

Courtesy *Technique*

PROFESSOR C. M. SPOFFORD

considerable number of experiments made in the Institute laboratories and elsewhere. The book on "Stream Gaging" is written to fill the needs of the students taking the course in this subject given at the Surveying Camp at East Machias. It is believed to be the first textbook in English on this field of hydraulics. These two books together form a notable addition to hydraulic engineering literature.

The third edition of "The Theory of Structures," by Professor Spofford is in press and will be published soon. This edition contains much material not found in previous editions.

In view of the increased cost of tuition at the Summer Surveying Camp, a loan fund was established last summer to assist needy students to attend the Camp. This fund is intended to be a revolving fund, each student signing serial notes covering the amount borrowed, the total payments to be completed within two years after leaving the Institute.

A series of eight illustrated lectures on hydraulic engineering with special reference to the experimental work of the German hydraulic laboratories, given by Dr. George Henry deThierry, formed one of the important events of the year 1926–27. Dr. deThierry is professor of Harbor and Canal Engineering and of Hydraulics of the Technische Hochschule at Charlottenburg, and came to Technology to deliver these lectures at the invitation of the Institute. One of the most eminent hydraulic engineers of Europe, he is president of the German Society of Harbor Engineering, and of the German Society of Civil Engineers, and is also vice-president of the United German Engineering Societies. His professional engagements have included services as chief engineer for the City of Bremen, Germany, in connection with the regulation of the river Weser, and 15 years of membership in the International Technical Commission of the Suez Canal Company.

A permanent bench mark was constructed at the Institute site during the year by driving a hollow steel shaft to the underlying bed rock and filling it with concrete. The bed rock at the point chosen between Building I and Charles River Road was found to be 112 feet below the surface, and the shaft was driven 10 feet farther into the rock, giving a total length of 122 feet. The height of the bench mark has been determined by representatives of the United States Coast and Geodetic Survey. This bench mark will prove valuable to engineers in Greater Boston by furnishing a point of known and unchanging elevation from which to establish levels for building and engineering construction, particularly in the large areas of filled land adjoining the Charles River in Cambridge and Boston. It will also be of value in investigations of vertical changes in the earth's surface, and in this respect will supplement studies of the movements of the earth's crust already started at the Summer Surveying Camp. The upper 6 feet of the bench mark is suitably protected against frost by a vitrified clay cylinder with a Ford meter box cover suitably inscribed, the latter having been presented to the Institute by the Ford Meter Box Company of Wabash, Indiana.

Professor Hale Sutherland, who was on leave of absence last year while serving as Acting Head of the Civil Engineering Department of Robert College at Constantinople, resumed his duties as Associate Professor of Structural Engineering at the opening of the present year.

CHARLES M. SPOFFORD.

Editorials

THE AVIATION BOOM

With the opening of the Institute in the fall of 1926, the course in Aëronautical Engineering, commonly known as Course XVI, made its official bow with an enrollment of 70 students. After the furor of registration for the present year had died away, it was found that 167 had chosen Course XVI, an increase of almost 140 per cent over the previous year. That the course should grow year by year is to be expected, but such a phenomenal growth in so short a time commands attention.

The explanation is fairly simple. The aviation industry, growing slowly but steadily, had received comparatively little notice from the average man until the transatlantic flights brought it into the limelight. After Colonel Lindbergh's spectacular feat, the country clamored for news of this latest development. The present condition and the past history of American flying became front page material for every paper in the country, and aviation was "played up" to the American public in a way that surpassed previous publicity in any field.

In the wave of enthusiasm which swept the country, aviation was hailed as a thing of the future whose growth would be even more rapid and more astounding than that of the automobile or motion picture industry. It is not surprising that many young men should turn to this new field in the hopes of reaping the profits which come the way of the first in any great development.

Perhaps, if the papers had been a little more conservative in their statements, the increase in registration for Aëronautical Engineering might not have been so high. If instead they had pointed out that the industry was already overcrowded with designers and engineers, and that many plants survived only through contracts for government work because the civilian demand was not large enough to support them, our potential Lindberghs, Fokkers, and Loenings might have thought twice before choosing aëronautics as their vocation. We do not attempt to predict a pessimistic future for aviation, but we do feel that the publicity and general attention which has recently been diverted toward the industry has led to a greatly exaggerated view of its immediate future.

In the new members of Course XVI's defense, however, we might point to the fact that many technically inclined men have heretofore felt a lack of romance and adventure in Engineering. Aëronautics, in its new coat of many colors, has, to them, fulfilled this need.

OUR PROFESSIONAL SOCIETIES

In the last issue of the TECH ENGINEERING NEWS, Professor Jackson stressed the privileges and benefits to be derived from a professional society. After reading it, there was not much doubt left in our minds as to why we should join our professional society. But on looking around the Institute we began to wonder whether the same reasons held for all the undergraduate professional societies. We decided "no."

The Mechanical Engineering Society has turned into a class in applied parliamentary law. They hold a meeting once a year to elect officers. Someone had an admirable amount of courage when he put it in *Technique* under the heading "Professional Societies." Of all the blatant examples of sheer lack of inertia that is the worst that we here tolerate.

On the other hand, we can readily recognize the advantage of belonging to the Aeronautical Society, the student branch of the A. I. E. E., the student branch of the S. A. E., or Corporation XV. They have been giving their members the privilege of hearing outstanding men in the profession, of going to Sectional Society meetings, and of taking an active part in the meeting.

The other societies with their habitual inspection tours and banquets can easily find their place between these two extremes. It might be well for all the societies to realize more fully that the first law of thermodynamics is universal in its application, and that Professor Jackson's most potent words were "one takes out of a situation in proportion to what he puts in." Does it not logically follow that if our societies allow their members to become parasites, they will die?

THE COVER

Our cover this month, by James Charles Flaherty of the Stone and Webster organization, is a sketch of the track entrance to the generator room at Connowingo. It gives an excellent impression of the scope of the project, as it brings out some of the detail of such an undertaking.

FLOODS AND RESEARCH

The comparatively recent floods in New England and the Missisippi Valley are poignant reminders of a huge problem that has not been attacked scientifically. Up to the present time, the three methods of attempting to control the Mississippi have been: first, the building of levees; second, the revetting of concave banks; and third, the removal of sand bars. In spite of the latest disaster these methods have been about ninety-nine per cent efficient. But the cost has been tremendous, and the cost to apply them to only the most threatening parts of the river would be inconceivable. Besides, there is nothing certain about their dependability.

The problem is not one of finding better and more economical ways of doing these three things, but of studying the hydrodynamics of rivers and of applying the findings. This can be done in the laboratory, as the Germans have partly proved, if each element of the problem is taken separately. It is the only way it can be done effectively and without involving terrific expense.

Since men of the Institute have been prominent in solving many of the problems connected with flood control in the past, would it not be most fitting for the Institute to establish a laboratory where the special hydraulics of rivers could be studied? Even if no laboratory is established, may we remind the undergraduates that this specialized branch of civil engineering has as promising a future as any branch of engineering. Our government at the present time is desperately in need of men with the facts of research behind them, and the wheels of government move so slowly that there is still time for present undergraduates to seriously consider this phase of engineering.

ELECTIONS

The Tech Engineering News takes great pleasure in announcing the following elections:

To the Editorial Staff: N. D. Fitz-Gerald '31, J. H. Dodge, Jr. '31, J. W. Robins '31, W. E. Yelland '30, A. H. Kuhnel '31, C. E. Grosser '31.

To the Business Staff: C. R. Wood '31, N. B. Haskell '31, H. E. Raymond '31, G. M. Orne '31, J. W. Cook, Jr. '31, J. P. Dahlberg '31, P. C. Smyth '31, G. A. Speedie '31.

To the Editorial Board: Assistant Editor, M. R. Boyer '29; assistant managing editors: C. F. Edlund '30 and B. K. Couper '29.

To the Business Board: Assistant advertising manager, A. A. Horne '30.

The Engineering Field

Abstracts from the leading professional and trade journals

An Innovation in Urban Transportation is the result of an experiment of a Mexican transportation company in gasoline-driven trolleys. They have proved entirely satisfactory; thirty-seven are in use today, and more have been ordered.

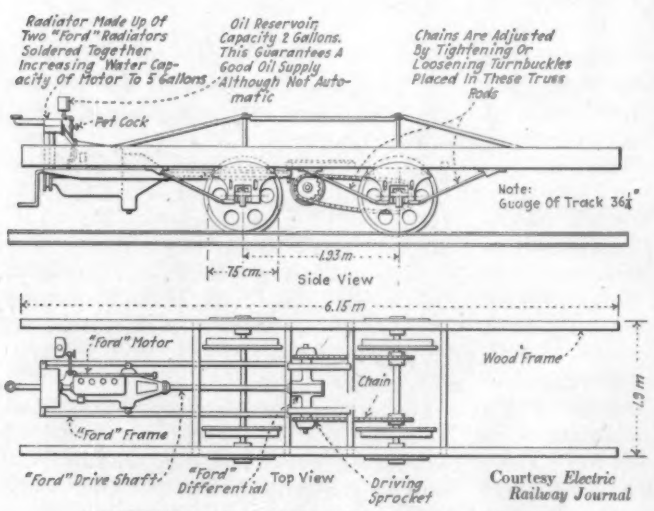
The level ground on which the cities using them are built permit the use of a Ford 22½ horsepower motor. Ford parts are used on the trolley wherever it is found practical to do so. The motor is hung from a steel frame by Ford hangers, as it is in a touring car or a truck. The rear axle is shortened, and new especially designed sprockets keyed on. A chain drive connects these sprockets with the wheels. Both types of Ford differentials are used.

The control levers are mounted vertically in the ends of the car. The spark and gas levers pass through the floor, thence to the magneto and carburetor. A new magneto is used for starting; the Ford magneto is used for lighting purposes.

Since a single radiator is insufficient for the needs of the motor, two Ford radiators are soldered back to back. This gives ample circulation. The gasoline tank is mounted vertically in the vestibule, and the oil tank is also mounted in the vestibule.

Manipulation of the cars is nearly the same as that of a Ford automobile. Clutch and reverse are operated by pedals located in the floor. The Ford brake is replaced by a hand brake, such as was found in all trolleys before the advent of the air brake.

Gas and oil consumption are satisfactory, considering the conditions under which the motor works. The maximum speed is about fifty-five kilometers per hour; the average gas consumption is one liter for every four kilometers.


Radiator Made Up Of Two "Ford" Radiators Soldered Together Increasing Water Capacity Of Motor To 5 Gallons
Oil Reservoir Capacity 2 Gallons. This Guarantees A Good Oil Supply Although Not Automatic
Chains Are Adjusted By Tightening Or Loosening Turnbuckles Placed In These Truss Rods
Pet Cock
Note: Guage Of Track 36"
1.93 m.
.75 cm.
Side View
6.15 m
"Ford" Motor
Wood Frame
Chain
1.9 m
"Ford" Frame
"Ford" Drive Shaft
"Ford" Differential
Top View
Driving Sprocket
Courtesy Electric Railway Journal

METHODS OF COUPLING FORD PARTS TO DRIVING WHEELS

Ammonia Leaching for Zinc Ore had been tried as early as 1878, but it was not until recently that the process became a commercial success. For over fifty years investigators have studied the dissolution of zinc compounds by ammoniacal solutions. They discovered that zinc oxide may be dissolved by ammonium carbonate, and the zinc recovered by distillation of the solution as basic zinc carbonate. The carbonate may be converted into the oxide again by calcination. This process affords a convenient method for obtaining a commercial zinc oxide of high purity from zinc ores.

The ores are roasted and then oxidized by a hot air blast. The fumes from the furnace contain zinc oxide, lead, a little silver, cadmium, bismuth, antimony, and a few other metals. The fumes are then tested with ammonium carbonate solutions in steel covered tanks. This dissolves an amount of zinc equivalent to the ammonia, while the lead and silver form a residue and can be filtered out. Copper and cadmium may dissolve, but they are plated out on scrap zinc. By evaporation of the solution, the ammonia and some of the carbon dioxide are driven off, and the zinc is precipitated as a basic zinc carbonate. The carbonate can be converted into the oxide by calcination at a fairly low temperature. The quality of the zinc oxide depends somewhat upon the original ore treated, and also upon the amount of iron introduced during the distillation by corrosion of the equipment. Sometimes the product requires further refining.

The ammonia and carbon dioxide driven off during distillation are collected and used again. However, some of the ammonia is lost by being fixed as ammonium sulphate by some of the soluble sulphates formed in the roasting of sulphide ores. The total ammonia losses are low in general, but on high grade fumes they sometimes run as high as twenty pounds per ton of material treated. In general, the consumption of reagents in pound per pound of zinc as basic zinc carbonate should not exceed the following:

NH_3 — 0.025 pounds
CO_2 — 0.25 pounds

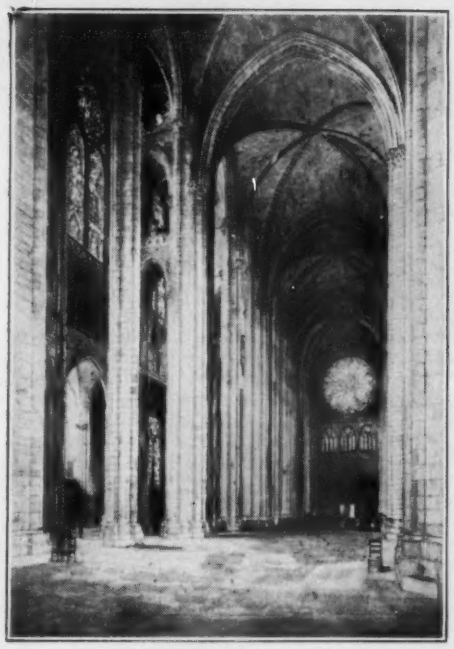
With an improvement in equipment and technical supervision, the process should soon be as successful as the ammonia leaching of copper ores, which has been used commercially for several years.

Recent Developments in the Rayon Industry have enabled textile manufacturers to place better and more varied products on the market. It has been found that cellulose-acetate silk, when treated with nitric acid under certain conditions of strength and temperature for a very short time, shrinks and becomes fuller to the hand. When a fabric composed of a mixture of cotton and cellulose-acetate silk is treated in a similar manner, the cotton is unaffected by the acid, but is compacted by the shrinkage of the silk. This fabric when finished closely resembles crêpe de chine, not only in appearance but also in texture.

Formerly, fabrics of this nature were mercerized without danger to the cellulose-acetate silk through saponification by caustic only by carrying out the process rapidly at a low temperature. It is now possible to mercerize them at the usual temperature and rate by impregnating the cloth with a liquid which protects the silk but does not mix or interfere with the mercerizing solution. The liquid used is usually either benzine or one of its homologues.

A method which is used to mercerize only cotton-rayon fabrics in which the rayon is of the viscous type, consists of mercerizing the cloth with caustic before the viscous rayon has been desulphurized. Then the rayon is desulphurized in 1% solution of sodium nitrate between 80° and 90° C. Finally, the goods are washed and bleached in the usual way. The success of this process depends upon the fact that viscous rayon which has not been desulphurized may be treated with concentrated caustic without injury to its luster, strength, or softness.

Cellulose-acetate silk is one of the most versatile of textile fibres. It has many peculiar characteristics which allow for novelty effects on finished goods made from it. There are certain volatile chemical compounds which cause the cellulose-acetate to swell and soften, but they do not dissolve the fibre and thus destroy it. So fabric composed wholly or in part of the ace-



Courtesy *Scientific American*

THE MAJESTIC NAVE

Note the noble line of piers, 86 and 98 feet high, which assist in carrying the vault. The nave is 96 feet in width.

tate silk is treated with these chemicals and a design impressed upon it. In this manner an embossed effect is obtained, and the fabric retains the pattern when finished. Cloth thus treated is found to withstand laundering as well as ordinary cloth.

Due to these recent developments and the use of improved machinery and methods of finishing, artificial silk can be produced of such quality that the layman cannot distinguish it from real silk, and even the technical textile man is forced to resort to laboratory tests to ascertain the real nature of the material.

The Cathedral of Saint John the Divine which is nearing completion in New York City, is an excellent example of the carefulness of present-day engineers and architects. Having learned many lessons from the builders of the Middle Ages, they are attempting a cathedral on a scale which has hitherto only been dreamed of. When it is finished it will be the third largest in the world, but the proportions of its nave, alone, are grander than anything which has been tried before. The load upon every pier, the thrust against every buttress has been calculated with close exactness. The crushing strength and safe limit of loading of each kind of stone are known, and every part is so constructed that every element in the vast structure will have an extremely wide margin of safety.

The main piers measure 11 feet by 16 feet 3 inches, and consist of a heavy outer casing of Indiana limestone with an inner core of massive squared granite blocks, each weighing from 5½ to 7 tons. Not only is the work set in a concrete mortar that hardens to the consistency of the stone itself, but, at each course it is tied together by galvanized iron clamps. The side piers are of amazingly slender proportions and to prevent their buckling under their loads it was decided to make each course of a single granite block of a maximum diameter of seven feet.

It is expected that the cathedral will stand for at least five thousand years, and it is safe to say that the pillars will remain as plumb as they are today for all time.

New Diesel Engines of Unique Designs have recently been placed on the market for marine purposes. The engines are remarkable for their efficiency and simplicity, and have been designed to obtain the greatest degree of compactness without sacrifice of strength or accessibility to moving parts. In addition, they are noteworthy for their freedom from vibration.

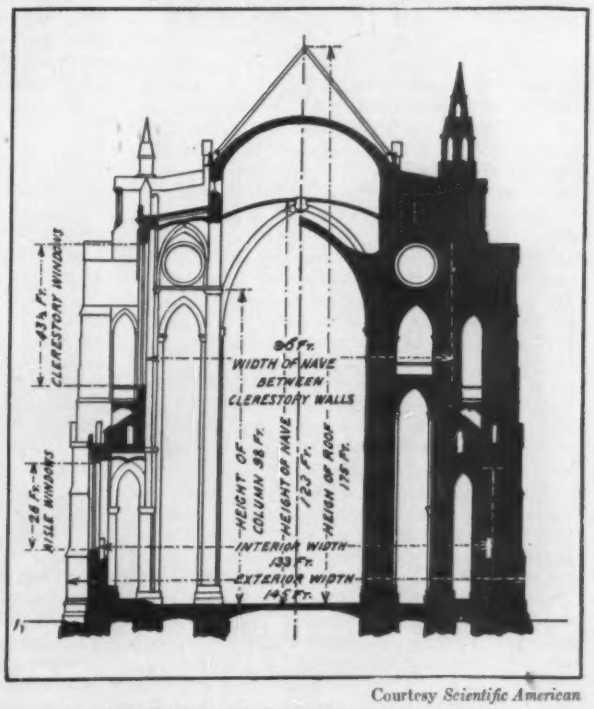
The construction is strongly reminiscent of automotive practice, both in external appearance and in mechanical details. The cylinders, of which there are six and eight in the two models, are arranged in line, and cast en bloc. The crankshaft is forged in two sections, each part serving one block of cylinders. Bearings are unusually large, especially on the crankshaft where they are 12¾ inches in diameter. Ball bearings are used in several places. Individual cylinder heads are used which greatly facilitate repairs by eliminating the necessity on former engines of dismantling the valve operating gear and water connections. The heads are baffled internally to assist in the distribution of the cooling water. The camshaft is located overhead and is operated by a chain drive from the center of the crankshaft. Reversing is accomplished by moving the camshaft laterally in eccentric bearings by an air ram. This brings the reversing cams into position.

Operation of the engines is extremely quiet and free from vibration. No critical speeds were found up to 350 r. p. m. during the tests, and at the normal speed of 300 r. p. m., they run as smoothly as the most delicately balanced eight-cylinder automobile engine.

These new Diesels represent the latest development of this remarkably efficient type of internal combustion engine, and are a big advance in marine power plants.

Beryllium promises to be materially reduced in price through the discovery of new electrolytic methods of production. The metal, which is one-tenth lighter than aluminum, is soon expected to seriously undermine the popularity of its rival. Unlike aluminum, it is highly resistant to salt water, metal destroying liquids, and fumes. It is light gray in color and takes a polish like high grade steel. Under the influence of heat it expands at about the same rate as cast iron. Thus an interesting possibility is its use for light weight pistons inside the iron cylinders of automobile engines in which capacity it will present far less engineering difficulties than do the present types of light pistons which expand at a rate different from that of iron.

The Discovery of a New Mineral — Rasorite — which was found in one huge deposit of some eight million tons, has recently been reported from the Mohave Desert. Chemically, Rasorite is known as boron tetra-hydrate, and before this time has been entirely unknown in nature because of the lack of the necessary conditions under which it is formed. The mineral as formed consists of striated crystalline bars some of which are as large as ordinary stove wood. All that is required to change it to commercial borax is to recrystallize it with the addition of water. As the other important borax ores, colemanite and ulexite, require several expensive chemical processes to change them, it can easily be seen that the present high price of borax and, consequently, that of its by-product pyrex glass, will be materially reduced.


CLERESTORY WINDOWS
86 Ft.
WIDTH OF NAVE BETWEEN CLERESTORY WALLS
HEIGHT OF COLUMN 98 Ft.
HEIGHT OF NAVE 123 Ft.
HEIGHT OF ROOF 135 Ft.
INTERIOR WIDTH 133 Ft.
EXTERIOR WIDTH 145 Ft.

Courtesy *Scientific American*

SECTIONS THROUGH THE NAVE

There are no flying buttresses as in medieval cathedrals. The space they would cover is here included in the nave, rendering this the most spacious nave in the world.

Recent Books

This department conducted in co-operation with the faculty

PYROMETRY. *By* WILLIAM P. WOOD AND JAMES M. CORK *of the University of Michigan. McGraw-Hill Book Co., Inc. 1927, 207 pages. Illustrated.*

While there are many reference books covering the subject of pyrometry, there has long been a need of a textbook on this subject in our engineering schools. This book is largely a compilation and rearrangement of material from various reference books and trade catalogues, particularly Technologic Paper No. 170 of the United States Bureau of Standards, with the purpose of making a suitable textbook for college use.

After a brief description of the temperature scale and fluid thermometers, the major portion of the book is devoted to a rather extensive discussion of thermoelectric, resistance, optical and radiation pyrometers. Numerous diagrams and illustrations show methods of practical application of the various instruments. One chapter is set apart for the important subject of temperature recorders and controllers, illustrated from various trade catalogues.

The last portion of the book takes up the subject of thermal analysis and transition points, indicating the different types of heating and cooling curves as well as a description of the furnaces used for this work. The final chapter has a very brief description of the refractories used in connection with pyrometry. An appendix contains useful tables of boiling and melting points, types of pyrometers used in different industries and a few temperature entropy tables for the common thermocouples.

At the end of each chapter, a number of experiments are described that could be performed in a suitable laboratory and there are also a number of questions designed to test the student's grasp of the work.

This text on pyrometry fills a long felt need of a book suitable for classroom work and it should prove of considerable aid to instructors of this subject.

THE MATHEMATICS OF ENGINEERING. *By* RALPH E. ROOT, *The Wilkins Co., Baltimore, Md. 1927. 540 pp. Price $7.50.*

In the past many books have been written with similar titles and if one took the trouble to glance through them he gained the impression that an engineer needed but little mathematics. At the present time, engineers are finding that they do need mathematics and that the real fundamental principles of mathematics are more useful to them than formulas. Professor Ralph E. Root of the Graduate School of the United States Naval Academy has presented, in this volume, what he thinks an engineer should know and we cannot help commending him on the choice of material. The principles of calculus are well presented and the student who masters it will certainly understand the calculus and be able to use it. The book is the outgrowth of a set of notes used at the Graduate School. The men taking the course there have all had a previous course in Analytics and Calculus so that, as would be expected, this book is on a higher level than the usual elementary calculus.

The work naturally divides itself into two parts: the first part forming a review of elementary calculus, analytics and some parts of algebra; the second part (nearly half the book) takes up more advanced topics, *i.e.*, topics not usually given in a first course. This book takes a place between elementary calculus and advanced calculus. There is a good list of exercises for each chapter. Many of the exercises and illustrations worked out in the text are taken from engineering and mathematical physics. The last five chapters are devoted to differential equations both ordinary and partial. So far as the solution and properties of differential equations are concerned this is adequate for most engineering problems. A chapter is also devoted to complex quantities and periodic functions in which the electrical engineer will find the mathematics for his circuit theory. There is also a chapter on Treatment of Empirical Data in which the elements of the theory of least squares and the fitting of curves to data are given. At the end of each chapter a good list of references is given.

C. L. E. MOORE.

TIME AND MOTION STUDY AND FORMULAS FOR WAGE INCENTIVES. *By* STEWART M. LOWRY, B.S. in I.E., M.E.; HAROLD B. MAYNARD, M.E.; G. J. STEGEMERTEN. *First Edition. McGraw-Hill Book Co., Inc., New York. 372 pp.*

"This book is designed to fulfill a dual purpose as a textbook for technical schools and a handbook for practical men and factory executives," thus the authors fully outline the scope of this text. To make their work complete and clear they have gone into considerable detail on all points and have carefully included examples of each step in the course of computing time values and their subsequent use.

The book is divided into three parts. In Part One the authors have taken up a very complete, almost minute, description of the fundamental principles of time study, its applications in general and to machine shop work in particular. After giving a brief outline of the needs for time study, considerable care has been taken by the authors in describing the type of man necessary to properly take time measurements and to sell the time study idea to the workmen who will directly benefit by its use.

Each step of the actual time studies made is described in detail, instruments used are noted, dangers pointed out, and methods for obtaining best results emphasized. In fulfilling the purpose of textbook, there has been little left to the experience of the reader, necessary information has been written in full. The authors have been careful to emphasize the viewpoint of the workman and to point out ways of bringing satisfaction both to employer and employee. The last part of this section deals specifically with the methods of tabulating the results of the separate studies for the purpose of determining fair time values for jobs under immediate consideration and for future reference in determining fair allowances on new work.

Part Two consists of a full description of the use of, and ways of obtaining, formulas from the time study records for the purpose of applying standardized values to new work. The formula is a means of concretely expressing the result of long experience in a particular class of work and s a means of using this experience in obtaining quickly a fair time value for a specified job. The authors have emphasized the necessity for accuracy and have outlined clearly the proper means of computing the value used in the formulas. This section of the book contains formulas that have been successfully applied to such subjects as panel mounting, milling machines, alloy castings molded on bench, storeroom, winding A. C. filed coils, metal ratio, and ship castings. Each case is detailed in full.

The final chapters are concerned with a discussion of organizing for time study work, wage payment plans, and job analysis. Here again is emphasized the obtaining of a competent personnel. The discussion of the wage payment plans points out the necessity of an incentive system in order to obtain the coöperation of the workmen. Several plans are reviewed and their advantages and disadvantages noted. The "group" system of wage payment is also considered in detail. Job analysis is recommended as a means of eliminating duplication of jobs and other evils.

The book as a whole presents a careful analysis of the factors relating to time study and the benefits derived from its use.

THE CHEMISTRY OF THE NATURAL AND SYNTHETIC RESINS, *By* T. H. BARRY, A. A. DRUMMOND, M.Sc., A.I.C., AND R. S. MORRELL, M.A., Ph.D., F.I.C. *196 pp. D. Van Nostrand Co. 1926. New York.*

Although resins are technically important, their chemistry has not been thoroughly studied, and there is need for much fundamental research in the field. In this book the authors present a systematic and attractive account of the information now available, which should be stimulating and useful to students, teachers, and industrial chemists.

Section 1 deals with natural resins. A brief discussion of their botanical origin is given in the introductory pages. The first and second chapters describe, in a general way, the physical properties, chemical constitution, and chemical tests, such as determination of solubility, acid, saponification and iodine values, and the action of heat. In the pages which follow detailed information about hard, semi-hard, spirit-varnish, and soft resins, as well as natural lacquers, is presented. Turpentine, rosin, and shellac are discussed at length. In connection with each substance, the sources, preparation, chemical composition, solubilities, technical treatment and uses, and analytical tests are considered. The authors describe only those natural resins which are used in varnishes. Details of manufacturing procedures are not stated.

A brief summary of some recent developments in synthetic resins of the formaldehyde-phenol, hardened rosin, coumarone-indene, acrolein, furfural, and urea types is given in Section III, which constitutes about one-third of the book. The authors emphasize the relationships between chemical structure and resinification. Manufacturing methods are briefly outlined, and the technical significance of each type of resin is mentioned. The chapter on methods of testing synthetic resins deals with hardness, elasticity, water-resistance, melting-point, brittleness, rubbing tests, analytical methods, the action of solvents, acids, alkalies, heat and light. It is the writer's opinion that the second section of the book is too brief and that the reader should supplement it by studying Carleton Ellis' detailed and comprehensive volume on "Synthetic Resins and their Plastics," which gives much information about the industrial aspects of the subject.

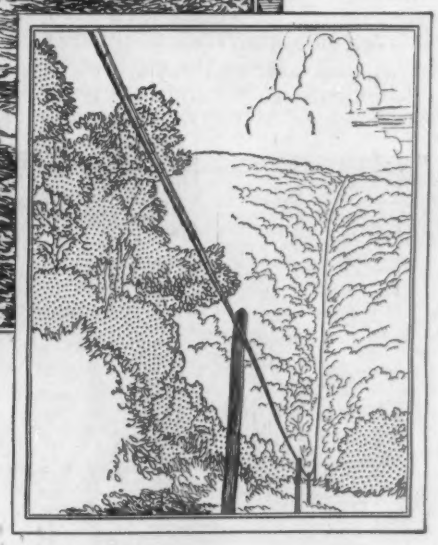
H. W. UNDERWOOD, JR.

PYROXYLIN ENAMELS AND LACQUERS. *By* SAMUEL P. WILSON, M.A., PH.D. *D. Van Nortrand Company, Inc., New York, 1927. 247 pp. Price $3.50.*

This book aims to fill the need for a manual covering the manufacture and application of present day lacquers and enamels. This subject has become of great importance with the universal use of pyroxylin lacquers for the finishing of automobiles and other manufactured products. The book covers only the field of enamels and lacquers, making no attempt to discuss the celluloid, film or explosive industries. The book is divided into two parts, the first covering pyroxylin, its solvents, plasticisers, and the different coloring pigments. The second part is devoted to a review of bronzing liquids, leather dopes, metal and wood lacquers, the application of pyroxylin solutions and a discussion of the different analytical methods available for the testing of these substances.

This book is invaluable to all who make or use pyroxylin lacquers, as it contains the latest information available on this subject.

Today telephone cables cross country that Daniel Boone knew.



To the Daniel Boone in every man!...

It is still the day of the trail blazer. In the telephone industry pioneers are cutting new paths in the knowledge of their art.

This industry is continually on the threshold of new ideas, with each development opening up a vista for its explorers to track down.

Their activity will be as engineers in laboratory research and plant operation, but also in supervisory and executive positions—planning the course of activity for groups of men and carrying the burdens of administration.

The responsibility and opportunity of management take on an increasing importance in an industry such as this, where forward-looking leadership must point the way to ever better public service.

BELL SYSTEM

A nation-wide system of 18,000,000 *inter-connecting telephones*

"OUR PIONEERING WORK HAS JUST BEGUN"

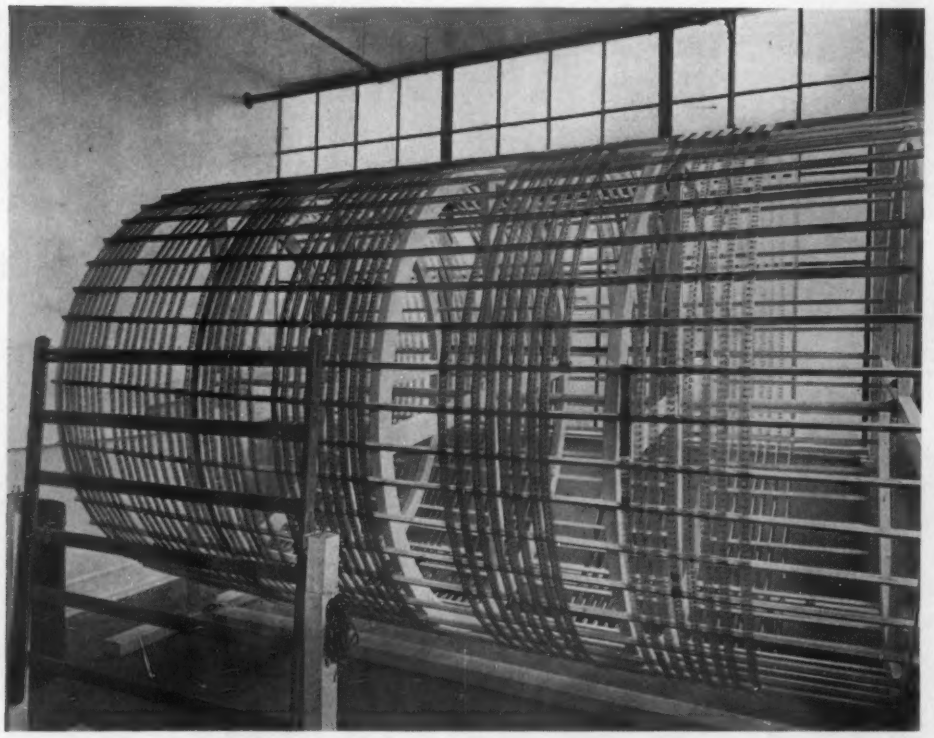
The Technicolor Process

(*Continued from page 294*)

including extra thickness, failure of the red and green images to lie in the same focal plane, tendency to buckle with age and to scratch on one side during projection. In the double-coated film the red image is carried on one face, and the green on the other face of the celluloid. If one side is scratched, a bright streak of color corresponding to the image on the other side appears on the screen. In the case of the single-coated film, both colored images are combined in the single gelatin layer so that it is impossible to separate them mechanically. Scratches, therefore, produce the same effect as in black and white.

The outstanding difficulties of motion picture photography in natural colors are practical rather than theoretical. Many theoretical methods for accomplishing the desired result have been represented in the patent literature for years. The greatest achievement of the Technicolor group lies in overcoming myriads of practical obstacles which lie in the path of the actual application of theoretically promising ideas. These difficulties are of all sorts, ranging from the details of technique in manufacture to the psychological characteristics of motion picture directors and audiences. Processes which will work perfectly in the laboratory may fail completely in the motion picture studio or theatre. The practicability of the present Technicolor process has been demonstrated by its use under all conditions of lighting, action and projection. At the present time Technicolor pictures can be made with exactly the same light intensities and projected in exactly the same manner as black and white pictures.

The leading spirits in the Technicolor enterprise are Technology men. Credit for the initiation of the work belongs primarily to Dr. H. T. Kalmus and Dr. D. F. Comstock, both of the Class of 1904, and both of whom have been professors in the Department of Physics at the Institute. Dr. Kalmus has been president of Technicolor since 1916. Other Technology men who were prominent in the early developmental efforts include J. A. Ball '15 and E. A. Weaver '15. Mr. Ball is now manager of the California end of the business, which is primarily concerned with negative and camera work. The present writer, representing the Class of 1912, has been identified with the work from an early period, and has been largely responsible for the development of manufacturing operations. Other Tech men have contributed to the work at various times, and it is highly probable that the name Technicolor is derived from its association with Technology.



DRYING RACKS FOR COLOR FILMS

The manufacturing plants of the Technicolor Company are located in Boston and Hollywood. The Boston plant has a large capacity for turning out finished positive film, while the Hollywood plant is devoted primarily to the preparation and finishing of negative, although it comprises a complete positive unit for the production of so-called "rush prints." These are viewed by the directors and producers in the usual manner shortly after the negative has been taken. These plants are provided with the most modern equipment for film processing, having been built expressly for the purpose for which they are being used.

The present Technicolor process may be outlined briefly as follows:

The first step, naturally, is to obtain a negative. This requires, first, supersensitized panchromatic negative film, and, second, a special camera so devised as to record upon the negative the color aspects of the scene which is to be photographed. This camera produces simultaneously from the same point of view two geometrically identical images of each instant of the action. One of these images represents the green values, while the other records the red values. The pictures are taken in succession on a single strip of film, which is naturally of twice the length of a corresponding black and white negative. When this film is developed, the negative pictures are in terms of a black silver deposit showing no color.

The next step is to make two prints from this negative, using a special printer which transfers the red record series of images to one positive film and the green record series to another such film. Each of these films is of normal length. These two films are run through special solutions which develop the latent images in such a manner as to yield *gelatin reliefs* instead of the ordinary deposit of metallic silver which characterizes a black and white motion picture positive. These reliefs represent the gradations of the positive color aspects in terms of the thickness of gelatin, this being low in the high lights and higher in the low lights. The older "double-coated" Technicolor process involved the cementing together of two such corresponding relief strips and the subsequent dyeing of one side red and the other green. Upon looking through such a composite dyed relief film, the result is a two-color reproduction of the original scene, showing all possible or existing gradations between pure red and pure green.

However, the present method is to utilize the two separate relief films as "matrices," in a manner somewhat similar to that in which the separate

(*Continued on page 316*)

Resists Corrosion

THIS picture, taken in the salt marshes near Kearny, N. J., shows two lines of 30-inch Cast Iron Pipe replacing pipe made of other material. The alternate exposure to the action of salt water and air is a severe test.

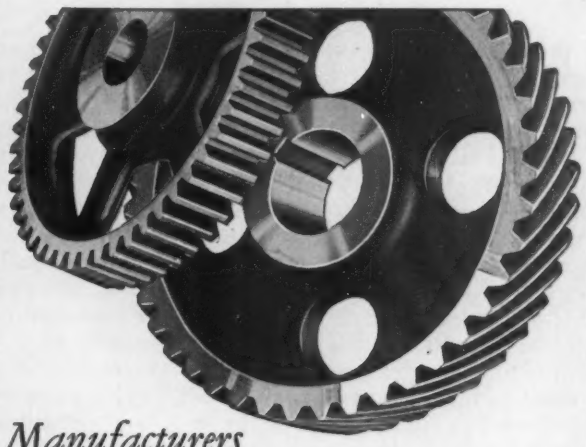
While the pipe shown in the picture is subjected to unusual corrosive influences, all underground pipe must be able to withstand corrosion to a greater or less degree. Cast Iron Pipe has this quality. It does not depend on its coating to resist rust; the material itself is rust-resisting. The first Cast Iron Pipe ever laid is in service today at Versailles, France, after two hundred and sixty years' service.

THE CAST IRON PIPE PUBLICITY BUREAU
Peoples Gas Bldg., Chicago

CAST IRON PIPE

Our new booklet, "Planning a Waterworks System," which covers the problem of water for the small town, will be sent on request

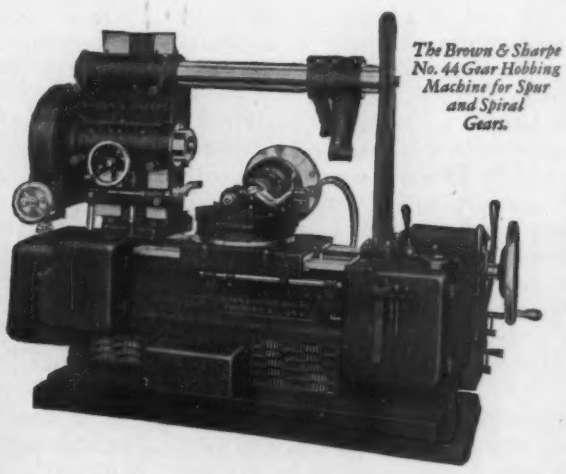
Send for booklet, "Cast Iron Pipe for Industrial Service," showing interesting installations to meet special problems



Manufacturers get better Gears—and more per dollar of investment by Hobbing with Brown & Sharpe Machines

WHEN the cost of gear cutting equipment is estimated the modern way, on a sustained production basis, Brown & Sharpe Gear Hobbing Machines show a low enough cost per gear to convince the most skeptical production engineer. Many up-to-the-minute features enable these modern producers to deliver more and better gears per dollar of investment.

It will pay you to become familiar with the advantages of using Brown & Sharpe Gear Hobbing Machines. Write us direct for a catalog describing all three sizes.



The Brown & Sharpe No. 44 Gear Hobbing Machine for Spur and Spiral Gears.

BROWN & SHARPE MFG. CO.
PROVIDENCE, R. I., U. S. A.

Sources of Fixed Nitrogen

(*Continued from page 299*)

than the equivalent of 40,000 tons of nitrogen.

Cyanamide must, therefore, be considered primarily as a raw material for the production of ammonia and ammonium products such as the sulphate or phosphate, with a total cost so excessive that these cannot compete on a large scale with other sources. Opportunities of reducing the cost are confined to a decrease in the power requirements and in this respect no revolutionary changes are anticipated. No construction of new cyanamide plants on a large scale is at all likely and it is probable that only a small proportion of the productive capacity now in existence will be operated, except during periods of abnormally high prices for fixed nitrogen.

For the production of ammonia through the direct synthesis of hydrogen and nitrogen under pressure by the Haber process or by its several modifications, there are now in operation several large plants. Other plants are built and still others are contemplated.

Contrary to general impression, coal and coke, not hydroelectric power, are today the most important factors in fixing nitrogen by this method. Of the total capacity, about 500,000 tons of fixed nitrogen are based on the production of hydrogen from coal and coke and only approximately 20,000 tons are based on hydrogen produced from the electrolysis of water.

Dr. Louis Jones, president of the Nitrogen Engineering Corporation, stated in a paper before the International Conference on Bituminous Coal held at Pittsburgh in January, 1926, that where both power and fuel are available under identical conditions the cost of producing ammonia and ammonium sulphate is approximately the same whether using coke at $3.00 per ton or utilizing power at $10.00 per h. p. year, or $6.30 coke compared with $15.00 per h. p. year for power, or $9.60 coke compared with $20.00 per h. p. year for power.

There are few places in the United States or in the world where prime power can be obtained at less than $20.00 per h. p. year and many places where coke is available at $6.00 per ton. Hence, it is evident that except at those few places where by-product hydrogen may be available, or where special conditions may allow very cheap power which cannot be utilized for other purposes, the further extensive expansion of the direct synthesis of ammonia will be by the use of coal and coke as the source of hydrogen.

Briefly outlined, the process consists first in producing water gas containing nearly equal volumes of hydrogen and carbon monoxide with a few per cent each of carbon dioxide and nitrogen. This is mixed in proper proportions with ordinary producer gas, consisting chiefly of nitrogen with twenty to thirty per cent of carbon monoxide and smaller proportions of hydrogen, carbon dioxide and methane.

Steam is added to the mixture and it is then passed through heat interchangers and a hot catalyst, consisting usually of iron oxide containing small amounts of chromium and cerium, which causes the water vapor and carbon monoxide to react to give hydrogen and carbon dioxide.

The resulting gas, consisting of nitrogen and hydrogen in the approximate proportions of one to three by volume, mixed with thirty per cent of carbon dioxide, two to four per cent of carbon monoxide and up to possibly one per cent of other impurities, is treated under pressure to remove all but the hydrogen and nitrogen. The carbon dioxide is removed by water and caustic alkali and the carbon monoxide and other impurities by an ammonia solution of copper carbonate or formate.

The combination of the purified hydrogen and nitrogen to form ammonia is brought about in the presence of a simple catalyzer in a converter at high pressures varying from 100 atmospheres to as high as 1000 atmospheres. The German plants operate at 200-250 atmospheres pressure, the temperature of the catalyst being maintained at about 600°C–700°C. The Syracuse plant operates at about 100 atmospheres pressure. A plant at Niagara Falls operated at 750 atmospheres.

The proportion of nitrogen and hydrogen converted to ammonia in one cycle is dependent on the pressure, temperature and length of time of contact with the catalyzer, varying from 5 per cent up to 40 per cent. The ammonia in the mixture leaving the converter is removed by cooling and condensation or by absorption in water, the uncombined nitrogen and hydrogen returning to the converter after the addition of new volumes of the gases equal to that removed as ammonia.

Since the reaction in the converter is exothermal, the process can be autothermal by passing the gases leaving the converter and those entering through heat interchangers. After the reaction is once started it is unnecessary to add any further heat to the system.

Under the present day development of the process with bituminous coal at $4.00 per ton and coke at $6.50 per ton, ammonia may be produced in this country for about 4.5 cents per pound. This cost includes depreciation and amortization charges, equalling about 12½ per cent of the capital invested in the plant, and the cost of producer gas, water gas, and the synthesis and recovery operations.

The chief outlet for synthetic ammonia in this country has been for refrigeration purposes, but this can absorb only a relatively small proportion of the total synthetic ammonia production of the world. The chief outlet for ammonia must be through fertilizer channels, as ammonium sulphate, ammonium phosphate or other special forms of fertilizer products.

With a cost of 4.5 cents per pound and a cost of $9.00 per ton for sulphuric acid (60°Be), this being the average cost of producing 60°Be acid from brimstone, at the present price of that raw material, the cost of producing ammonium sulphate bagged and ready for shipment to the consumer is about $40.00 per ton of sulphate. This is approximately $1.95 per unit of nitrogen contained therein. The cost of the German plants are probably less than the above by from $5.00 to $10.00 per ton, or by from 25 cents to 50 cents per unit of nitrogen.

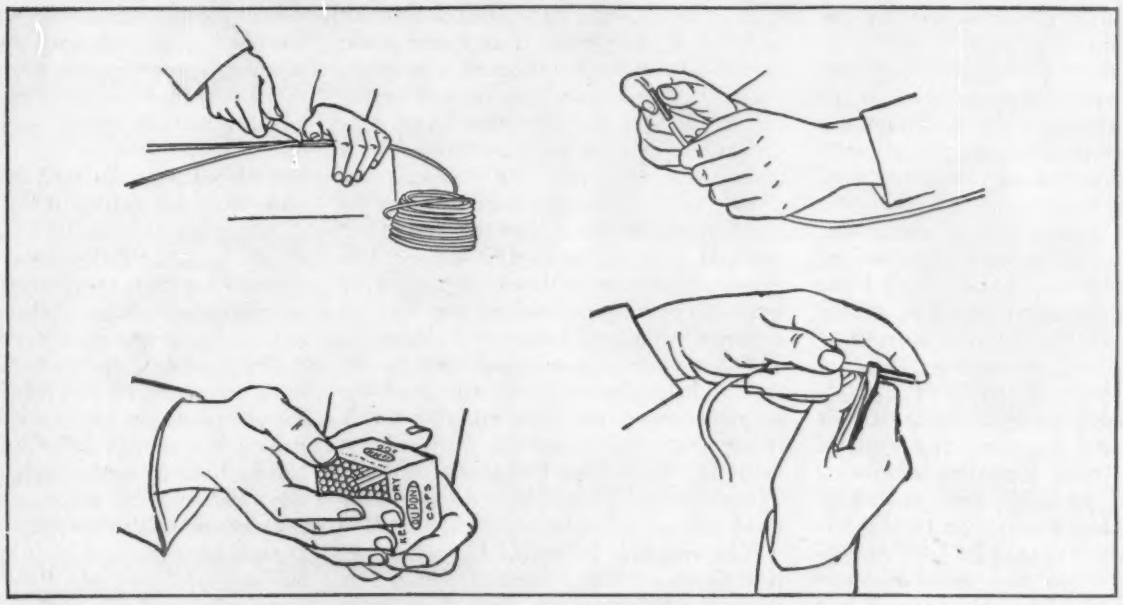
Let us now compare these costs with that of fixed nitrogen in Chile nitrate. The resources in Chile of nitrate of soda are sufficient to supply the demands at the same rate as during the last ten years, for at least a century and probably longer. The nitrate is found associated with other more or less soluble salts mixed with inert material as sand, clay and gravel, the raw material mixture being known as caliche. The average per cent nitrate in the caliche being treated has been decreasing from upwards of 30 per cent, as existent when the deposits were first worked, to an average of about 16–17 per cent under present day practice. Very little high-grade caliche is remaining in the nitrate fields.

The original Shanks process which was first introduced in the nitrate field, when high grade material was available, has been the one process, with some minor modifications, which has been universally used up until the last year, for treating the material regardless of grade or different physical characteristics. The extraction of nitrate with the Shanks process has been relatively low, averaging not over 60 per cent of the nitrate from the average caliche.

In this process the nitrate of soda is leached from the caliche by boiling water or "mother liquor" in rectangular steel tanks, in a counter current

(*Continued on page 314*)

Making Primers



Lesson No. 2 of

BLASTERS' HANDBOOK

PRIMING a dynamite cartridge seems like a very simple job when you watch a professional blaster—a thrust into the cartridge, a blasting cap crimped onto the fuse and inserted into the hole, and the fuse tied to the cartridge with a piece of twine.

But each of these apparently simple steps requires experienced handling for the sake of efficiency and safety. Upon proper priming depends ***complete detonation, avoiding the pulling out of detonator, guarding against moisture, easy and safer loading of bore holes.*** There are two methods of detonating a charge—safety fuse and blasting cap or electric blasting caps.

Each step of the several methods of priming a cartridge is fully explained in classroom terms and clearly illustrated in Chapter Two of the ***Blasters' Handbook***.

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Sources of Fixed Nitrogen

(*Continued from page 312*)

leaching cycle, the pregnant solution of nitrate being cooled to allow the crystallization of the nitrate with the return of the mother liquor to the leaching cycle.

The difficulty of obtaining high extraction has been due principally to the sliming of the caliche in the boiling operation, which prevented both the complete dissolution of the nitrate and the efficient washing of the residue. The various modifications introduced to minimize the sliming difficulties, or to effect more efficient washing have only been partially successful in increasing the recovery of the nitrate.

With the Shanks process, treating the average grade of caliche now available, and under present day costs for labor, fuel and supplies, the cost of producing nitrate, including depreciation charges, bagging, transportation to the coast and loading on to ships is approximately $21.00 per ton, or approximately $1.30 per unit of fixed nitrogen. The Chilean government has collected an export tax of $10.40 per ton or 65 cents per unit of nitrogen, making a total delivered cost on board vessel of $1.95 per unit of nitrogen.

Water transportation to consuming point costs, including insurance and financing expense, from $6.00 to $7.00 per ton or 40 cents per unit of nitrogen. Hence the total actual cost of the nitrate c. i. f. ships at consuming countries is about $38.00 per ton or $2.40 per unit of fixed nitrogen. These are average figures for a production of about 2,000,000 tons of nitrate containing approximately 320,000 tons of fixed nitrogen.

It is not anticipated that labor costs, fuel costs, or other items entering into the operation will be materially decreased in the future.

Hence, with the export tax remaining as at present, the total cost of nitrogen in Chile nitrate by these Shanks process plants will be between $2.15 and $2.40 per unit of nitrogen, of which 65 cents per unit is represented by the government tax.

During the last year, there has been put into operation at the plant of the Anglo-Chilean Consolidated Nitrate Corporation near Tocopilla, Chile, a process developed by the staff of Messrs. Guggenheim Brothers, which process is effecting substantially high recoveries of nitrate from the caliche and much lower costs of production.

This plant was the result of a great amount of research work on the problem by the Guggenheim staff both in this country and at a pilot plant in Chile during 1922 and 1923. With the exception of a few minor difficulties such as are incident to the introduction of any new process, the operations of the new plant have been successful. Extractions of 95 per cent of the nitrate from average caliche and over 90 per cent of the nitrate from lower grade caliches have been obtained with substantially lower costs per unit of material treated than in the Shanks process and consequentially much lower costs per unit of product.

Briefly, the process consists of crushing the caliche to a size that is easily leached, separating the fines from the coarse, leaching the coarse in a counter current cycle by downward percolation in large tanks and treating the fines by agitation leaching and washing in filters. The temperature of the leaching is relatively low, around 35°–40°C, being that which can be attained by using the waste heat available from the Diesel power plant and compressors used for refrigeration.

The solution is cooled by refrigeration to about 0°C, the solutions to and from the refrigeration operation passing counter-current through heat interchangers. The nitrate is obtained from the cooled solutions as a very white crystalline product, higher in actual nitrate content than the average product of the Shanks' plants.

By this process, even when applied to lower grade caliche than generally available for the Shanks' plant, the actual cost of production is believed to be about half that for the Shanks' plant production. This means a lower cost of production by at least $6.00 and probably nearer $7.00 per ton than the Shanks' process producers.

Hence, with the same cost for delivery to the coast, export tax and ocean freight charges per ton as applied above to the Shanks' plants production, the cost of nitrate by the Guggenheim process plants should be less by from 35 cents to 45 cents per unit of fixed nitrogen than by the Shanks' process plants, or approximately $1.85–$2.00 per unit of nitrogen.

This cost is comparable to the cost of fixed nitrogen in ammonium sulphate based on producing ammonia by the direct synthesis method using $4.00 coal and $6.50 coke as the source of hydrogen and nitrogen. Both of the above costs include ordinary depreciation and plant amortization charges, but no interest on the capital represented.

The above figures indicate that with the present export tax on nitrate, the Shanks' process plants are at a disadvantage and the Guggenheim process plant is on a competitive basis with synthetic ammonium sulphate produced under cost conditions existing in the United States, assuming that the value of nitrogen per unit in one is equal to that in the other product, under keen competitive conditions.

During the last six years in the United States, nitrogen in the form of nitrate has averaged $3.05 per unit, while nitrogen as ammonium sulphate has averaged $2.60 per unit. With this differential, however, the proportionate use of nitrate nitrogen has decreased and that of sulphate or ammonium nitrogen has increased, which would indicate that the differential must be decreased for nitrate nitrogen to hold its proportionate share of the world's market for fixed nitrogen.

An important factor to be considered with reference to the relative value of nitrate nitrogen and ammonium nitrogen is the recent development in the production of nitric acid directly by the oxidation of ammonia. Approximately one-third of the nitrate imported into this country has gone into the manufacture of nitric acid. With ammonia available at less than 5 cents per pound, the cost of producing nitric acid therefrom is less than from nitrate of soda even at $20 per ton delivered, and an increasing production of nitric acid from ammonia may be anticipated in the near future. In fact, in Germany and other European countries the use of ammonia for that purpose is very general.

Having cheap nitric acid from the oxidation of ammonia, it will be relatively easy to proceed to the manufacture of nitrate of lime for fertilizer purposes. With cheap ammonia there will also be greater incentive to develop concentrated fertilizer products, such as the phosphates of ammonia, containing two elements desired for fertilizers.

At the present time, the German plants are producing and exporting a product known as Nitrophoska, containing the three important fertilizer elements, Nitrogen, Phosphorus and Potash — a concentrated fertilizer. A specially prepared mixture sent to the United States contained 15.9 per cent nitrogen, 32 per cent phosphorus anhydride and 16.3 per cent potash. Such concentrated products are possible through the use of ammonia, phosphoric acid and high-grade potash salts, and will undoubtedly have a wide market as the advantages of concentrated fertilizer are better appreciated.

The fixation of nitrogen in this and other countries is only in its beginning. There are other possible sources of hydrogen which may ultimately allow even lower costs than those obtainable in the use of water gas and producer gas derived from coke and coal.

Another source of hydrogen which

(*Continued on page 318*)

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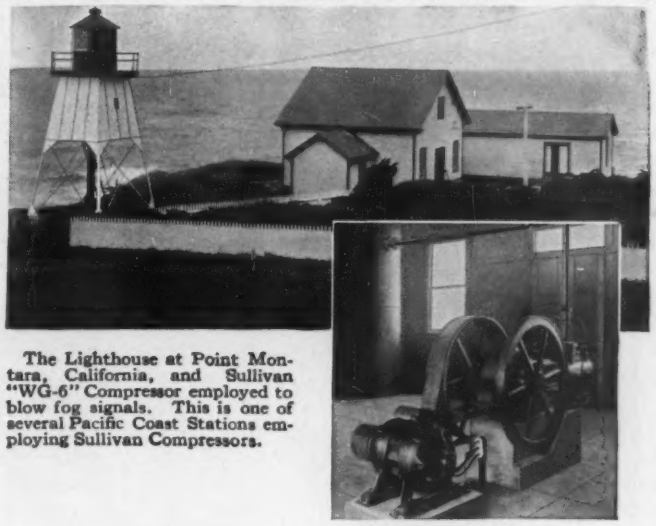

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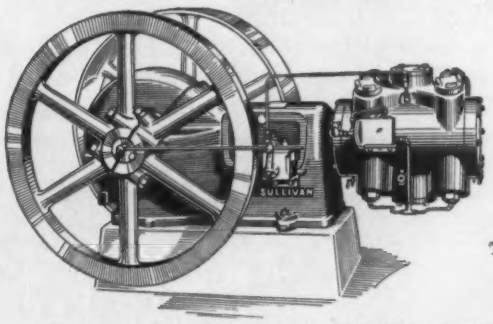

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164 S. Michigan Ave., Chicago

The Technicolor Process

(*Continued from page 310*)

metallic plates of a color half-tone printing set are employed. The two matrix strips are placed in an automatic machine which impregnates one of them with a red dye and the other with a green dye. The red matrix is then brought into contact with a celluloid film bearing a single transparent layer of gelatin. The red dye is transferred by diffusion into this gelatin layer after which the red matrix is removed and the green one is applied in the same manner. The resulting double impression upon the original "blank" provides the finished film which is employed in the theatre projectors. No further operations are necessary.

It is obvious that the printing matrices can be used repeatedly so that the process is essentially of the so-called "photo-mechanical" variety. It has the advantage of a high degree of reliability, rapidity of operation, and the production of a film which has physical characteristics practically identical with those of standard black and white motion-picture positive. Actual tests show that Technicolor single-coated film has a better projector life than black and white. This is to be attributed to the extra toughness of the gelatin coating and the absence of any protracted chemical treatment of the film in process. Definition, registration and colors values are very close to practical perfection.

It should be clear that this process requires a high degree of precision from beginning to end. Registration of the images is maintained throughout the process, from camera to finished film, by an automatic process. There is no color-fringing, and practical experience has shown that any subject which can be handled by black and white motion picture photography can also be reproduced in color by this process. Although natural color pictures should be expected to command a higher price than those in black and white, the present Technicolor process is adapted to a production of such pictures at a minimum cost. The final positive film contains no silver emulsion in any stage of manufacture, which effects considerable saving in labor and materials.

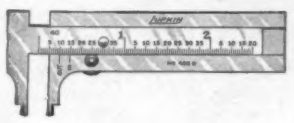
The photographic and color quality of the present Technicolor pictures are acknowledged by experts to be extremely good. Numerous producers, directors and artists have acclaimed them as perfect. While the two-color process, as at present used, has theoretical limitations in the rendering of certain colors, nevertheless the actual effects upon the theatre screen when the pictures are properly projected give a very close approximation to ideal results. Even scenics and other outdoor pictures are rendered in a very convincing manner. The effects obtained upon the theatre screen depend to a very considerable extent upon the type of light source which is employed. The best results are obtained with a plain, or uncolored carbon arc, or with a high efficiency mazda lamp. The so-called high intensity or cerium arc, which is used in the larger theatres, has rather too bluish a light to yield the best effects, but recent Technicolor positive has been provided with an overall tint which is designed to compensate for the bluish color of the high intensity arc, and yet at the same time not to interfere with the quality of the pictures with yellower light sources.

The future of motion pictures in natural colors must be regarded as very promising. It seems inconceivable that the screen art should permanently be restricted to black and white, with the consequent unnaturalness and limitations of mood. The function of the motion picture is either to educate or to stimulate the emotions, and the history of art in general shows that color is an indispensable factor in producing the best effects.

However, the motion picture industry is, at the present time, in a very prosperous phase of its history, in which its leading exponents do not feel the need for new technical improvements. Consequently, they are adopting the natural color film with notable slowness. Nevertheless, accumulated experience is showing that the use of color not only brings an enhanced box-office value, but enables the producer to economize on stars and other expensive features in dramatic production. Pictures in natural colors appeal to a wider audience than will those in pure black and white. Although the present motion picture audience, as measured in absolute numbers, is tremendous, nevertheless, considered as a fraction of the entire population, it is relatively small. A general enhancement of quality, both from the photographic and the dramatic standpoints, should bring about an important increase in the audience to which the motion picture can successfully appeal. Modern embodiments of the "talking motion picture," such as Movietone and Vitaphone, are a step in the same direction, and these should prove particularly effective when combined with natural colors. It is psychologically difficult to get a satisfactory fusion of the voice impression with a black and white image, but the desired effect is much more readily attained when the screen image is in natural colors.

The psychology of motion pictures, and particularly of natural color pictures, presents some very interesting aspects. When we come to think of it, it is remarkable that we are able to tolerate the unnatural form of representation which characterizes black and white photography. In effect, the ordinary motion picture screen reduces all observers to the level of complete color-blindness. However, the public

(*Continued on page 318*)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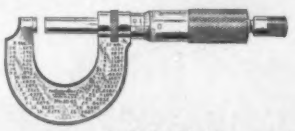

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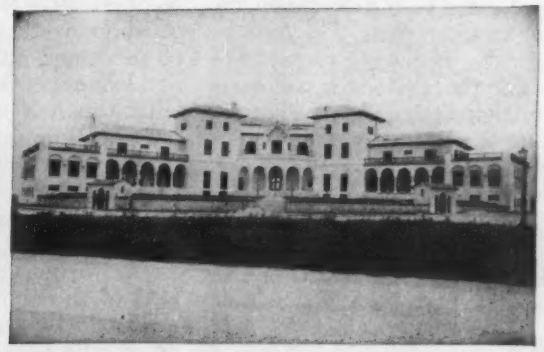

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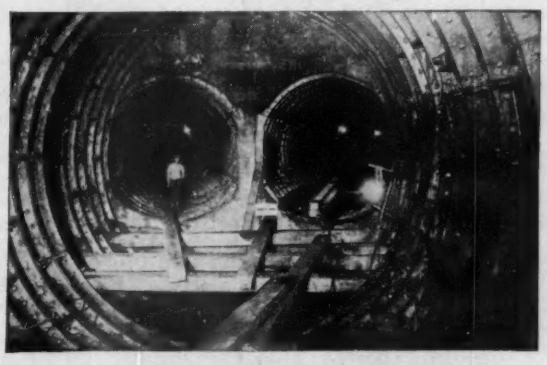

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Master Tools

(*Continued from page 302*)

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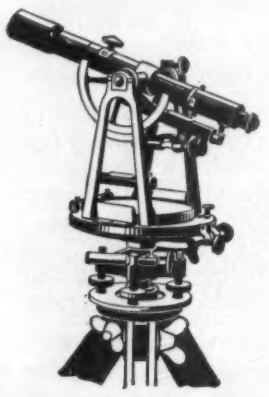

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Technicolor

(*Continued from page 316*)

has become so used to monochrome on the screen that producers fear that the introduction of natural colors may distract the attention of audiences from the ideas which the story is intended to suggest. Theoretical as well as empirical considerations show that this fear is unfounded, since the introduction of colors relieves the mind of the necessity of compensating for the unnaturalness of the black and white representation and leaves the imagination freer to deal with the less sensory aspects of the presentation. However, the attractiveness of colors in themselves, or as a media for delineating beautiful objects or scenes, permits the director to dispense with some of his dramatic tricks without loss of interest on the part of the audience.

The history of industry has shown repeatedly that neglect of research and factors leading to technical improvement in a commodity has reacted disastrously upon the individuals or organizations which have taken this attitude. During certain phases of its history an industry can consistently ignore the desirability of improving its product, but a time eventually appears when the failure to advance results in disaster. As examples, we may cite the fate of acetylene as an illuminant for automobiles, the plight of the phonograph industry when radio was first introduced, and the recent unfortunate experience of a certain prominent manufacturer of low-priced automobiles. The motion picture industry has been practically at a standstill technically for a decade, and it may be able to continue prosperously in this condition for some time longer, but eventually it is going to require the wholesale application of a forward step in quality to enable it to retain popular approval. The Technicolor process of motion picture photography in natural colors provides the requisite methods. This process is constantly being improved through the efforts of an energetic research staff and will keep ahead of all quality requirements which may be made upon it.

Fixed Nitrogen

(*Continued from page 314*)

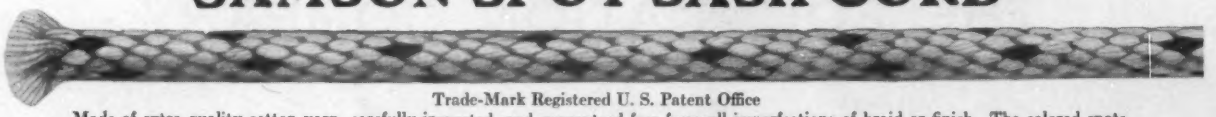
has been suggested is the natural gas in Louisiana and Texas. By cracking this gas to produce a form of carbon known as thermatomic carbon, a gaseous product high in hydrogen is obtained, which can be purified of residual gases and made available as a supply of hydrogen for ammonia.

There is also the probability that in certain localities where cheap power and phosphate rock may be available, as in our Pacific Northwest, there will be an important development of the Liljenroth process. In this process, phosphoric acid is produced from phosphate rock in an electric furnace operation with the simultaneous production of hydrogen as a by-product. By using this hydrogen for the production of synthetic ammonia, and combining this with the phosphoric acid it will be possible to produce a concentrated ammonium phosphate product which can be shipped long distances without incurring prohibitive freight costs per unit of fertilizer elements.

The demand for fixed nitrogen in the world's market is constantly increasing. It has increased 50 per cent in the last fourteen years and without doubt, will continue to increase in the future. Not only will the demand be greater in this country and in European countries, but there is the probability that in the near future there will be developed an important market for commercial fertilizer products in the Orient.

The increase in production of synthetic products will probably be in proportion to the increase in demand for fixed nitrogen, but there is little likelihood of the elimination of natural nitrate from the world market, as has been predicted in some circles. The writer anticipates a continuing demand for Chile nitrate at a price which will probably be sufficient to make profitable the production of a substantial tonnage, though probably not a pre-war tonnage, especially if produced by the Guggenheim or an equally efficient process, and more especially if there is also effected some reduction in the Chile export tax on this commodity.

SAMSON SPOT SASH CORD



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Object ~ ~

To inquire into the steps of manufacture taken to safeguard the uniformly high quality of Jenkins Valves.

Apparatus ~

A tour of inspection of Jenkins Bros. factory, Bridgeport, Conn.*

Procedure ~

Note that metal is analyzed by trained metallurgists before and after casting. Note that the design and construction are in accordance with sound engineering principles and practice. Note that research is being carried on constantly, that new features are being developed which are added to the product. Note that every completed valve is tested in actual operation and that only valves which make good in wide margin tests are allowed to leave the factory.

Conclusion ~

The steps of manufacture taken to safeguard the uniformly high quality of Jenkins Valves are sufficient to explain the confidence of hundreds of engineers who have made Jenkins Valves their standard valve selection.

**An invitation is extended to engineering college students to visit the Jenkins factory singly or in groups. If notification be given in advance, Jenkins Bros. will be pleased to make arrangements for a tour of inspection.*

Always marked with the "Diamond"
Jenkins Valves
SINCE 1864

Industrial Health Hazards

(*Continued from page 293*)

cal means such as ventilation; a better knowledge of the efficiency of different types of ventilating devices and their operation in the removal of dust, and lastly, the recognition of the fact that silicosis is an occupational disease and that those workmen who are disabled by it should be compensated.

This has been said to be the chemical age, and there can be little doubt but that the progress which has been made in industrial chemistry has brought many blessings to the world, yet these blessings have not been altogether without a tincture of evil. New processes which have been developed in the perfection of old methods have required the use of many new chemical compounds about which we know very little as to their effect on the health of the worker exposed to them. But of more importance is the fact that there has taken place within quite recent years a widely different procedure in the manner in which certain trades are carried on. An example of the effects of new methods in old trades can be found in the way spray painting has supplanted hand painting. In the past, painting was done by hand and the main hazard was that of the lead contained in the paint. Usually it was done by persons experienced in the painting trade and who at least knew the hazards connected with their work. At the present time spray painting has considerably changed this particular occupation, especially in the painting of automobiles. There is hardly a village so small at the present day which does not contain a shop where spray painting can be done, and in many places spray guns are owned by private individuals. In the majority of instances there is no attempt made by the operator to protect himself from the fumes of the spray, and he has not the least idea of the chemical nature of the material he is dealing with or the deleterious effect it may have on his health. Several years ago practically all of the spray paints contained benzol, which we know constitutes a dangerous industrial hazard. Fortunately, the work of the National Safety Council in coöperation with the Public Health Service has pointed out the danger from the use of this solvent, so that at the present time few of these paints contain benzol, although there are still on the market many inferior solvents which contain benzol to a dangerous degree.

The protection of public health in this instance must begin where the spray material is manufactured, and in this regard it is most interesting to know that several large industrial corporations have recognized this fact and are studying the harmful effects of their chemical products before they send them into general industry to be used. There are thousands of poisonous materials which are manufactured without constituting a health hazard to the workers who make them. This is an evidence of proper hygiene and sanitation applied under strict supervising. It is when dangerous substances are placed in the hands of the inexperienced workers who understand neither the health hazard connected with the material they are using nor the sanitary measures to be used in protecting themselves, that public health is menaced.

One of the most important health problems which confront industry at the present time is the question of industrial sickness. While prevention of accidents has received considerable attention, and in many industries shows a downward trend as the result of the safety-first movement, industrial sickness has been largely neglected. Studies of the United States Public Health Service have shown that we must expect an average absence from work among males of approximately seven days per year. The economic loss, therefore, to both employer and employee is tremendous, far surpassing the time lost from accidents. Here, as in the dusty trades, the respiratory diseases assume the first place in importance.

If we turn again to the mortality statistics to which we have previously referred, we find that tuberculosis

(*Continued on page 322*)

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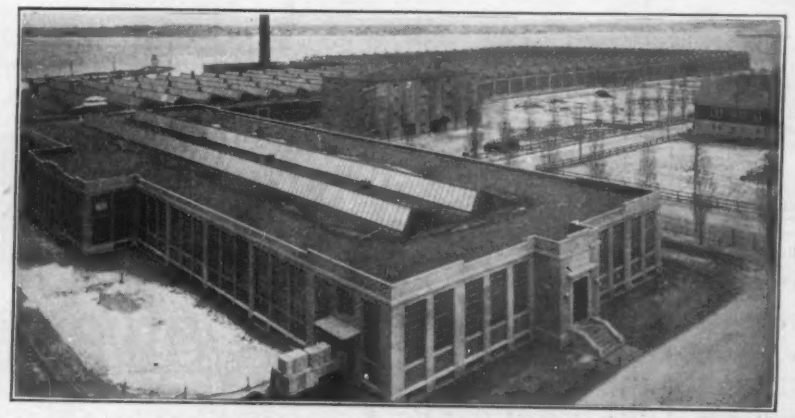

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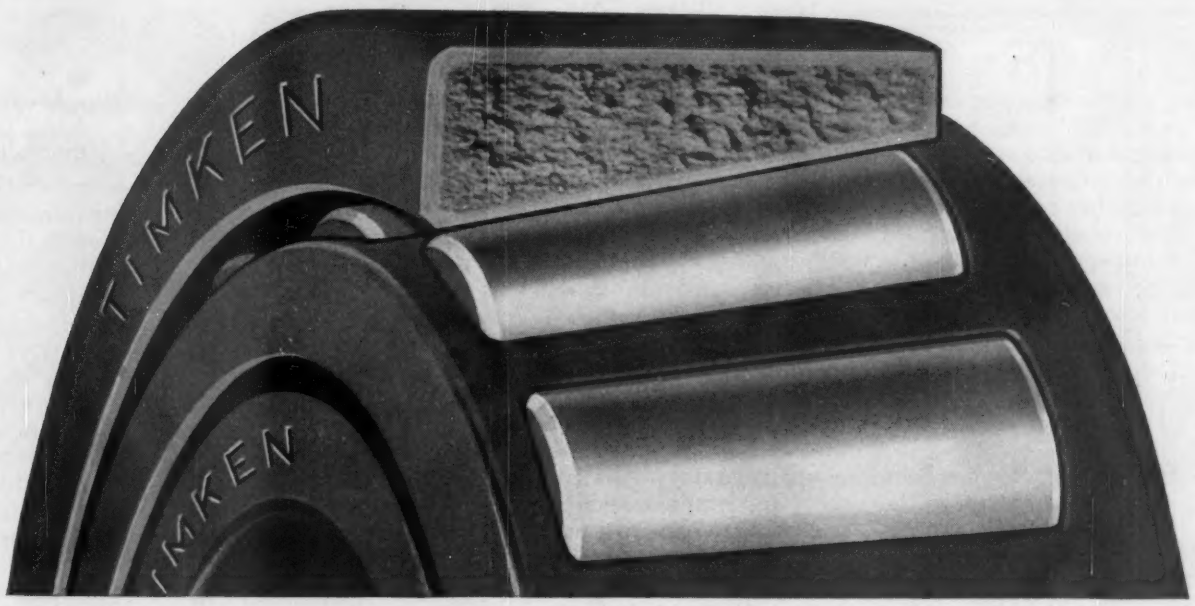

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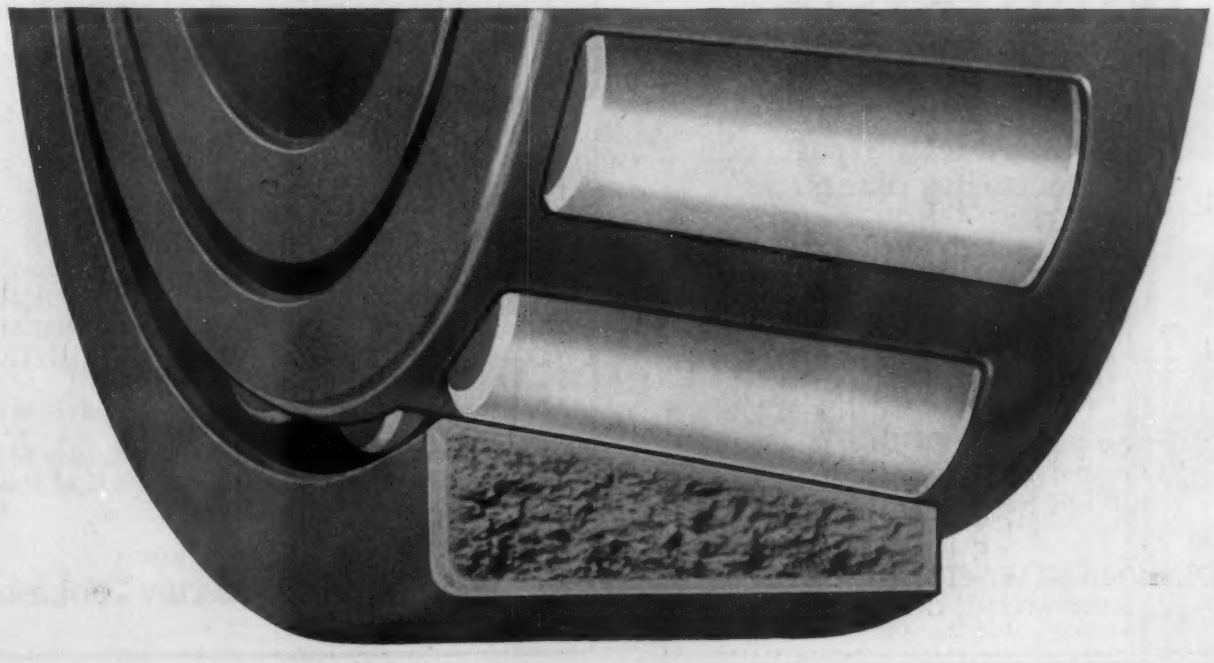

Industrial Health Hazards

(*Continued from page 320*)

causes approximately 14.8 per cent of all deaths; bronchitis causes approximately .82 per cent of all deaths; pneumonia causes approximately 8 per cent of all deaths; all other respiratory diseases, 1.3 per cent of all deaths; a total of 24.9 per cent or approximately one-fourth of all the causes of death — a quite impressive total when compared with the mortality rates from any other single class of diseases. How does this mortality rate fit in with the causes of sickness in the general industrial population?

The Public Health Service has been interested in the past ten years in the study of industrial morbidity. In coöperation with a number of industrial concerns we have accumulated sufficient records to allow us to have a fair view of the nature and severity of sickness in our general industrial population in this country.

For all of the diseases which incapacitate for eight days or longer, we find that tuberculosis causes 1.6 per cent of all illness; bronchitis causes 5.6 per cent of all illness; pneumonia causes 3.5 per cent of all illness; all other respiratory diseases cause 25.5 per cent of all illness. The importance of respiratory diseases has risen considerably and they now cause 36.2 per cent of the more severe diseases which keep the worker away from his occupation for over a period of a week. These records also indicate that the relative importance of the individual respiratory diseases in causing sickness has changed considerably. Whereas tuberculosis as the cause of death was by far the most important, as the cause of sickness it is of minor importance. Bronchitis has considerably increased, while pneumonia has decreased, but is that group of diseases classified as "all other respiratory" which is by far the most important, and of this group 19.5 per cent are classified under the heading of influenza and grippe.

If we follow this line of thought a little further and study the importance of respiratory diseases in those industrial concerns who have records of illness for one day or longer, the difference in mortality and morbidity data is still further increased. Tuberculosis now causes but 0.2 per cent of all illness; bronchitis, 1.7 per cent; pneumonia, 0.5 per cent; and all other respiratory diseases, 42.5 per cent, a total of 44.9 per cent. Here again, the relative status of the diseases included in the "all other" group, which causes approximately 42 per cent of the cases, has changed. The importance of influenza and grippe as the cause of sickness has dropped to 4.6 per cent, while the minor respiratory conditions such as colds and other diseases of the nasal pharynx cause approximately 38 per cent of all illnesses. There are several points in these comparisons which seem to be worth noting. Tuberculosis, which is the greatest single cause of deaths among respiratory diseases, falls to a position of least importance as the cause of sickness. On the other hand, minor respiratory diseases which occupy a relatively small position in the mortality rate, rise to first place — not only among the respiratory diseases, but occupying first place among all diseases as the cause of sickness.

The reduction in sickness as the cause of absence from work more or less resolves itself into the problem of control of the minor respiratory diseases, and this is a problem towards which at the present time our public health efforts have met with the least response.

There are unquestionably many factors in the causation of respiratory diseases which are entirely out of the

(*Continued on page 326*)

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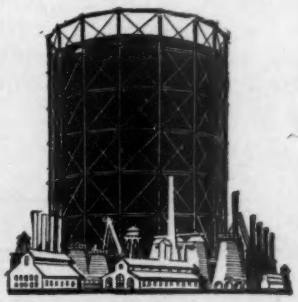

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The Ear and the Sensation of Hearing

(*Continued from page 297*)

nant one and consequently all tones would appear more or less complex.

The theory of maximum amplitudes was proposed by Gray in 1899. It assumes that the position of maximum amplitude of the basilar membrane varies with the frequency of the stimulating tone. This theory, with some modifications, seems to explain more satisfactorily the experimental facts of hearing. A displacement of the oval window causes a displacement of the mass of fluid in the scala vestibuli, which motion can be transferred to the fluid in the scala tympani, either through the basilar membrane or around the helicotrema end of the cochlea. If the frequency is small, which means a slow pressure change, the motion will be almost entirely transferred through the helicotrema. For higher frequencies and therefore more rapid pressure changes, most of the transfer will take place through the basilar membrane. There will be a well defined maximum displacement in the basilar membrane, the location depending on the frequency of the stimulating tone. The amount of stimulus of any nerve terminal may be taken as a direct function of the motion of the membrane at the point at which the nerve terminates. Two frequencies nearly alike will cause maximum displacements at adjacent points on the basilar membrane, the minimum detectable difference in frequency corresponding to the minimum detectable distance between maximum displacements. Knowing the length of the membrane and the frequency sensibility, and assuming upper and lower frequency limits, it is possible to plot a frequency distribution along the membrane.[8]

Suppose f_1 and f_2 are the lower and upper frequency limits, l_0 the total length of the basilar membrane, l the distance from the helicotrema to the point where a displacement corresponding to a frequency f takes place, and Δf the frequency sensibility. Then $\frac{df}{\Delta f}$ increments can be detected in a frequency range df, or the total number of increments between f_1 and f_2 will be

$$n_0 = \int_{f_1}^{f} \frac{df}{\Delta f}$$

Similarly

$$n = \int_{f_1}^{f} \frac{df}{\Delta f} \quad ,$$

But

$$n_0 = kl_0$$

and

$$n = kl$$

if we assume that the space interval between two disturbances just distinguishable is the same all along the membrane.
Therefore

$$\frac{l}{l_0} = \frac{n}{n_0} = \frac{\int_{f_1}^{f} \frac{df}{\Delta f}}{\int_{f_1}^{f_2} \frac{df}{\Delta f}}$$

Using values

$l_0 = 31$ mm.
$f_1 = 80$ cycles
$f_2 = 15{,}000$ cycles
$\Delta f = 0.003$

we may find 1 corresponding to any frequency f. A plot of such value is shown in Fig. 5. The abscissa represents the basilar membrane on a mm. scale from the oval window end (O. W.) to the helicotrema end (H.). We may also find the variation in amplitude along the basilar membrane for different frequencies. Suppose we draw a hypothetical curve, Fig. 6, of the displacement of the basilar membrane along its length in response to a primary tone of single frequency. This curve will have a maximum at R_1. Suppose in addition we have a secondary tone of different frequency and sounding with the primary. Curve *a* shows such a secondary which is loud enough to be heard when sounding alone, but is completely masked when sounding with the primary. Suppose, as in curve *b*, the intensity level of the secondary is raised until it is just perceptible when sounded with the primary. The maximum of *b* should then lie on the curve of P. Thus the secondary becomes an exploring tone, and by using a variety of frequencies for it, the primary curve may be obtained.

Using this method, the amplitudes of various portions of the basilar membrane, corresponding to different frequencies, have been determined, and are shown graphically in Fig. 8. The ordinate is the amplitude of the membrane for minimum audibility, but the scale is arbitrary. The dotted curve is the locus of the maxima for all frequencies. The curves become flatter at low frequencies, perhaps due to a mass motion of the membrane as a whole. The curves also become less definite at high frequencies. This is to be expected, as from Fig. 4 there is a sharp cut off at about 15,000 cycles.

Experimental evidence seems to support the theory of a maximum amplitude in the basilar membrane, corresponding to a definite frequency stimulating tone.

[8]Wegel and Lane, *Phys. Review*, February 1924.

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Industrial Health Hazards

(*Continued from page 322*)

province of industry, but one cannot study the Report of the New York State Commission on Ventilation, the rates of respiratory diseases in many occupations where humidity is an industrial health hazard by nature of the work process involved, and the overheated and under-ventilated workrooms without feeling that the part which occupation plays is no inconsiderable one.

It is not possible to continue this discussion of the health problems which confront industry into many fields, but the subject would certainly be incomplete if one failed to mention the importance of industrial dermatosis and the probable effect of certain occupations in hastening the degenerative diseases of late middle life.

The question of industrial dermatosis has not been accorded the importance as an occupational disease which it actually has. From one of our states whose reports on occupational diseases are quite complete, the records show that for the year 1926 out of a total of 1,304 occupational diseases reported, 669 — or over 50 per cent — were cases of industrial dermatitis. In many instances the chronicity of these diseases is such that the compensation paid for the period of illness at times equals or even exceeds that paid for fractures of the long bones.

Industrial dermatitis is found in widely diversified types of occupations. It constitutes a serious occupational disease among workers in sugars, candies, and in bakeries. It is found among metal workers and those who engage in the manufacture and handling of dyes, chemicals, and explosives. Workers exposed to fine dusts, especially those of certain woods and similar vegetable materials, and those engaged in the canning of vegetables, fruits, meats, fish, and other such products are also included in the exposed group. In fact, there are but few trades or occupations where susceptible persons may not find some causative agent which may produce dermatitis.

We are in need of research into this field, not only to give us a more definite knowledge of the various agents which cause occupational dermatitis, but, in addition, we need to know more of the nature of the pathological reaction and the reason for the difference in susceptibility of individuals which allows one person to develop the disease while his associate exposed under exactly the same conditions appears immune.

Lastly, in the discussion of the effect of certain occupations as they may influence or hasten the degenerative diseases of late middle life, we are entering upon a subject which is still largely speculative.

In many occupations where in the past we have had frank cases of acute poisoning such as those where lead, mercury, and benzol, are part of the industrial process, the progress of industrial sanitation has considerably eliminated the health hazard. On the other hand, in these same occupations it still remains possible for the worker to absorb small quantities of the poison and to do this over long periods of time without any visible evidence of such exposure. Such a condition can hardly be considered even a chronic poisoning, yet it is quite conceivable that this sort of exposure by continually unbalancing the normal functions of the body might in time manifest itself in the development of a greater amount of ill health from conditions which at the present time we do not associate with any industrial health hazard or in hastening the development of cardio-renal or cardio-vascular diseases in late middle life.

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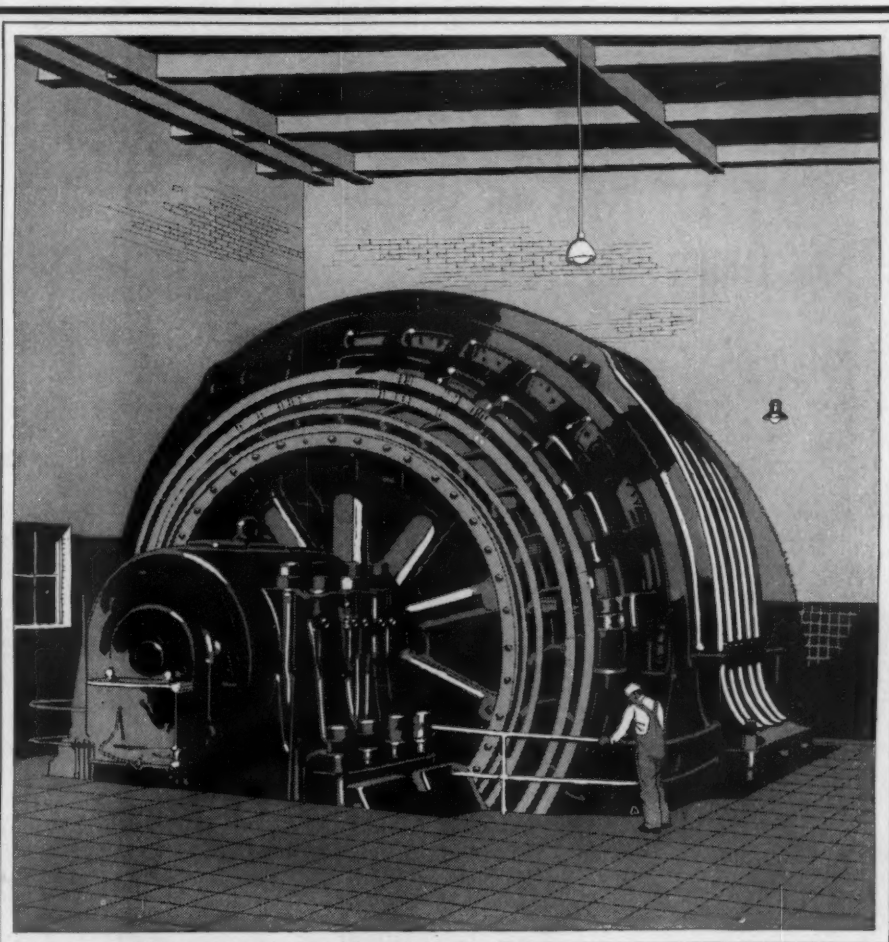

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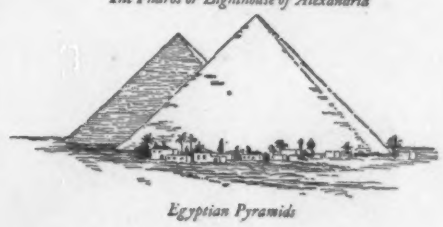

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